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SUPPLEMENT TO "THE ELECTRICAL ENGINEER," JUNE 29, 1888.

THE

ELECTRICAL ENGINEER:

A WEEKLY JOURNAL OF ELECTRICAL ENGINEERING,

WITH WHICH IS INCORPORATED

"ELECTRIC LIGHT."

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THE

ELECTRICAL ENGINEER

No. 1, Vol. I.—New Series. LONDON, JAN, 6, 1888. Price 3d.

NOTES.

Laniz.—The electric light at this castle has proved so succesful that the Emperor has decided to have the lighting extended to every room.

Lighting Trains in Russia.—The carriages and engines of the express trains on several of the Russian trunk lines are now lighted by electricity.

Stalybridge.—Mr. R. Platt's mills in Quarry-street are lighted by electricity, and the workpeople are unanimous in preferring the healthy light of electricity to that of gas.

Vienna.—Better accounts of the lighting of the opera are being received, and it is stated an extension of the lighting at the Town Hall has been decided upon by the municipal authorities.

The Jullien Accumulator.—In this apparatus, the plates supporting the active materials are formed of an alloy of 95 lead, 3·5 antimony, and 1·5 mercury, which is stated to be inoxidisable.

Shop Lighting.—Messrs. Chas. Baker and Co., of Fleet-street, have just lighted their premises by the eletric light. For this purpose the Jablochkoff lamps are used, and the current is supplied from Holborn.

Electrical Traction.—According the *Bulletin Technologique de la Société des Anciens Elèves des Ecoles Nationales d'Arts et Métiers,* the first experimental trials in the use of accumulators in electrical traction were made at Paris in 1882.

The Use of Telephones in America.—The manager of a New York telephone company states that on a recent day they received an average of 7¼ calls from each of their almost 7,000 subscribers. One subscriber made 68 calls and another received 131 calls.

City and Guilds Institute.—It is stated that the Hon. secretaries (Mr. W. P. Sawyer and Mr. John Watney) will not again offer themselves for re-election. The services of these gentlemen have extended over a period of upwards of ten years.

Experiments in Lighting Buoys.—The United States Lighthouse Department have had a series of experiments carried out by Lieutenant Willis to ascertain the value of lighting spar buoys by incandescent lamps, the current required being carried by cables from the shore.

Berlin.—This city will soon be the most brilliantly-illuminated city in Europe. The electric light is being fitted all along the Unter den Linden, and the Leipziger Strasse, which is upwards of a mile in length, is already illuminated throughout by electricity, which is to be introduced into all the principal streets and squares.

Londonderry.—The question of lighting the city by electricity is under discussion, and the solicitor has been instructed to put before counsel the existing agreements between the gas company and the corporation, and to obtain legal opinion as to the powers of the corporation to enter into the proposed scheme.

Sweden.—The town of Falu in Sweden is about to be lighted by electricity, a mode of illumination already adopted in two or three other Swedish towns. The installation is intended to comprise 50 arc lamps of 1,200 candle power each, and 300 incandescent lamps. The available power admits of a further increase of 200 incandescent.

Manchester "Wild West" Show.—Messrs. Hornsby and Sons have obtained the contract for the whole of the engine and boiler power for the electric lighting, heating, and ventilating of the large building which is being erected in Manchester for the purpose of the "Wild West" Show.

"Sithee for Thisen."—A man residing not a mile from Ringinglowe, whose younger brother had been working at the gas-house for about a fortnight, was one night walking throngh the town, and seeing the electric light for the first time, exclaimed to his pal, "By gum, awl tell thee what, lad—ahr niyper's made a bit o' difference tu t' gas be nahr. Sithee for thisen."—Jokes of the *Sheffield Telegraph.*

Electric Lamps for Submarine Work.—Experiments made at Newport with incandescent electric lamps show that if a 100-candle lamp is submerged below the surface of the sea the water is illuminated so that objects are visible in it at a distance of 150ft. It is expected that this device will be useful in warfare for determining the positions of, and destroying the cables of an enemy's mines.

Bournemouth.—The question of lighting the pier and pleasure grounds by means of the electric light is not to be allowed to drop. The experiments conducted by Messrs.

Mortimer, Shepherd and Co., during the past summer season were a great success, and it is hoped the Commissioners may soon see their way to permanently light the pier and the pleasure gardens.

Folkestone.—It is said that Folkestone is about to adopt the electric light, and that Messrs. Laing, Wharton, and Down, electrical engineers, Holborn Viaduct, E.C., will shortly put down appliances for 40 lamps of 1,200 candle power. These lamps will be run for a month on trial. It is also stated that a company is being formed for the purpose of supplying the electric light to Tunbridge Wells.

The Great Eastern.—The Great Eastern has been purchased by a Liverpool firm of metal merchants, whose intention is to break her up in the course of the next few months, and sell her as old metal. This magnificent vessel, whose gross registered tonnage is 18,915 tons, length 692ft., breadth 83ft., and depth 60ft., has been sold at the price of £16,100, or very little more than one-fourth of the sum it cost to launch her.

Institute of Electrical Engineers.—We hardly know when this new name is to take effect, but meanwhile the meetings announced for this year—to be held by the permission of the Institution of Civil Engineers at 25, Great George-street, Westminster—are fixed for the following Thursday evenings:—January, 12 and 26; February, 9 and 23; March, 8 and 22; April, 12 and 26; May, 10 and 31; November, 8 and 22; and December 13. On Thursday, January 12, the President (Edward Graves, Esq.) will deliver his inaugural address. The meeting on December 13 is the annual general meeting.

Glasgow Technical College.—A steam engine, which might be termed an educational engine, has been presented to this institution by Mrs. Russell in memory of her husband. The engine has been specially designed by Prof. Jamieson, of the college, as an educational machine to enable engineering students to make accurate tests not only of the weight of steam and (or) condensing water required under different circumstances, but also to drive the college dynamos for charging storage cells, and working electric arc or incandescent lamps. The engine will develope about five indicated horse-power with the present available steam supply, which is obtained from Mr. Gray's works adjoining the college; but all the working parts have been calculated for a steam pressure of 100lbs. per square inch, and 200 revolutions of the crank shaft per minute.

Heat of Frictional Electricity.—It has recently be shown M. Semmola that a metallic point through which negative electricity is discharged, giving in the dark the appearance of a star, is heated to a greater extent than a similar point traversed by a brush discharge of positive electricity. The metallic point used in his experiments was formed of strips of antimony and bismuth soldered at their extremities, and thus forming a thermo-electric couple. The elements of this couple being respectively connected with the terminals of a galvanometer, this was deflected when a discharge traversed the point. The discharge-point of M Semmola might possibly be utilised in indicating the electrical disturbances which precede thunderstorms; in this case tho metals composing it may advantageously be iron and plantinum.

Phœnix Fire Office Rules.—The 11th edition of these rules has just been issued, and it will be necessary for all those concerned in drawing out specifications, or in carrying out installations, to make themselves thoroughly conversan with the additions that are to be found in this edition. They are principally in regard to transformers, and are to be found in paragraphs 19 and 20 on pages 9, 10, and 11. We are glad to see an effort made in printing these rules to assist the reader to easily refer to the subject matter of the paragraph. We would suggest with the next edition that an index be added, when the pamphlet will almost come up to the ideal one according to American notions. As is well known, Mr. Musgrave Heaphy, who is responsible for these rules, is always willing to receive and consider any suggestions which may be put forward by practical men for their improvement.

Underground Wires.—The *New York Sun* says:—"A new device for protecting the cables of the electrical subway has been invented by Gen. W. W. Averell, U.S.A., anp will be tried on Spring and Green-streets. Spring-street has already been opened from Broadway to Green for the purpose. A boxing of hardened wood has been laid in the trench, and eighteen 2½in. iron tubes will be conveyed through it to carry the cables. The box will then be filled in with Trinidad asphalt melted up with sand. The mixture will be pured in hot, and worked in between the pises, entirely separating them and making a solid stone-like mass. Gen. Averell thinks it will withstand age, moisture and corrosion better than any of the preparations tried in different parts of the city. Most of the work throughout the city is similar in method to this new device, but substitutes cement for asphaltic concrete."

Telephones instead of Speaking Tubes.—The Equitable Telephone Association (Limited) have in hand installations of their Swinton Telephones, to be used as a substitute for speaking tubes in large buildings. Among these is an installation of 27 telephones in the new offices and ware rooms of the Co-operative Wholesale Society, and another is in the Hospital for Consumption at Ventnor. In the latter case all the various wards, the porter's lodge, and the house of the resident doctor will be connected together. The same company have quite recently completed a similar installation in the offices and warehouse of Messrs. Lyons and Co., 27, London-wall, the various floors of the warehouse, and the clerk's and private offices being all put in communication with one another. The many advantages that telephones have over speaking tubes both as regards range, efficiency, and ease in erection make it probable that installations of this description will multiply rapidly.

Canada.—According to advices from Canada answers are expected daily from the various Governments of Australasia whether they will co-operate with Canada in surveying the route of the proposed inter-colonial cable between Canada, New Zealand, and Australia. Cheaper telegraphic communication with the mother country would be gained by the Australian colonies than they now possess if they embark in the proposed enterprise. We need not point out the immense interest these negotiations have for the Eastern and Eastern Extension Companies. The proposed lines are not wanted, but it is probable they will be laid; and, if we might assume the mantle of prophecy, we should say the above-named companies will, by hook or by

crook, themselves lay the cables when they see their competitors are determined to carry out the project. Negotiations may go on for some years, but in our belief the ending will be as we have said.

Bute Docks, Cardiff.—At these docks arrangements are being pushed forward whereby the West, East and Roath Basins, together with the entrance locks, will in future be lighted by electricity instead of as at present by gas. Already the wires have been placed in position, and the erection is proceeding of a large engine-house in the vicinity of the Commercial Dry Dock, where will be laid down the necessary plant for providing the illuminating power. The adoption of the Brush system has been decided on and in all 20 lamps are to be hung, it being thought that these will suffice adequately to light up the large area over which they will be spread. Should the experiment be attended with satisfactory results, it is not improbable that in course of time the system of electric lighting will be extended until every portion of the docks is so illuminated. It is not, however, intended to remove the existing gas lamps even in the case of the ground marked out for the new departure. These will always be kept ready for any emergency. The lighting is expected to be ready in February.

Coming Home to Roost.—The nonsense that has been written and spoken about primary batteries, has given our gas contemporaries their opportunity. The *Journal of Gas Lighting* in its issue of December 27th, says: "Electricians have proved too much, and too often wrongly to be lightly credited now. Why, they have actually promised that their patrons should be able to obtain light for nothing, and make a profit into the bargain." Such promises are highly reprehensible when they are made, but we would respectfully say that *no electrician* has ever made such a promise; and that a broad distinction must be made between the promises of patentees and promoters, and those made by responsible electricians. The Journal we have referred to each week dishes up for its readers a most ludicrous article entitled, "Electric Lighting Memoranda," in which it is difficult to say whether animus or ignorance is most conspicuous. Of its lucubrations we can say, in its own words, "it is depressing to think of so much labour and genius being spent in vain."

A Hero of Science.—Under this title, Dr. J. B. Daly contributes a short paper to *The Welcome* on the story of the electric telegraph as embodied in the early struggles of Morse to get his invention introduced to the commercial world. The hardships Morse had to undergo will be understood by the following anecdote of Strother's. It seems Strother was a pupil of Morse, paid his dollars in advance, but owing to the non-arrival of a remittance the second quarter's money was delayed. One day Morse came in and said courteously :—"'Well, Strother, my boy, how are we off for money?' 'Why, Professor, I am sorry to say I have been disappointed; but I expect a remittance next week.' 'Next week!' he repeated sadly. 'I shall be dead by that time.' 'Dead, sir?' 'Yes; dead by starvation.' I was distressed and astonished. I said hurriedly, 'Would ten dollars be of any service?' 'Ten dollars would save my life; that is all it would do.' I paid the money, all that I had, and we dined together. It was a modest meal, but good; and after we had finished he said, 'This is my first meal for twenty-four hours.'"

Reduction of Chlorates by Electrolysis.—The following is an abstract of a paper from the proceedings of the Chemical Society. The authors of the paper are Mr. C. H. Bothamley and G. R. Thompson. "When a solution of potassium chlorate is reduced by means of the zinc-copper couple, a portion of the reduced chloride is converted into zinc oxychloride, which is insoluble in water but readily soluble in dilute sulphuric acid. The quantity of oxychloride formed is greater the more concentrated the solution. In order to avoid the error due to this cause, the chlorate solution is heated with the couple for about one hour, and pure dilute sulphuric acid is then added until the zinc hydroxide and oxychloride just dissolve. The liquid is filtered, neutralised with calcium carbonate and titrated with silver nitrate. Thus modified, the method gives very accurate results; the solution should not contain more than 1·5 gram of potassium chlorate in 25 c.c., and should just cover the couple."

Electric Light in a Flour Mill.—The Rock Mills, Londonderry, belonging to Mr. G. K. Gilliland, have just been electrically lighted by the Gülcher Company. Mr. Shannon has had charge of this work. The installation consists of a Gülcher dynamo, eighty 20 c.p. glow lamps, and an arc lamp of 2,000 c.p., the latter being placed in a mill yard. The dynamo is fixed on a sliding bed on the top of a wall about 3ft. thick, and is encased in a dust proof box, to prevent the possibility of igniting the flour dust floating in the air by the sparks at the brushes. At full output the machine is capable of supplying 150 20 c.p. glow lamps. The whole of the wiring has been carried out under the Phœnix Office fire rules, and where the conductors are carried from the old mill to the new mill they are encased in earthenware pipes lined with asbestos, whilst in other places they are carried in wooden casing. All the fittings, switches, and fuses are dust proof, so as to guard against the possibility of igniting floating flour by sparks caused on breaking circuit. There is a fuze to every lamp and to every branch wire, as well as to the main leads, whilst switches are fitted to the main poles, branch wires, and to every two lamps.

Carbon as a Positive Element.—In reference to this question and to its very important economical bearings, Mr. Desmond FitzGerald writes to point out that the difficulty is not in the oxidation of carbon by means of a fluid, nor even in its oxidation by a true electrolytic action. The only difficulty, according to his view, is in finding a cheap and effective negative element and depolarising agent. It is in fact of little use to utilise what is theoretically, and may be practically, the most economical positive element if a heavy expenditure is incurred in the negative element and its depolarisation. It may be said that in all primary batteries the efficiency of the negative element is a more difficult, if not a more important question than the selection of an efficient and economical positive element. In connection with the latter, the question of local action is also of great importance from an economical point of view. Probably these observations have been suggested by the considerations of the new carbon-consuming—and chlorate of potash consuming—battery of Mr. Willard E. Case, of which the E.M.F. is given as 1·25 volt.

Telephony in the Alps.—Telephonic apparatus has been installed with great success in the famous Hospice of

the Grand Saint Bernard. The Paris correspondent of the *Daily Telegraph* says :—Canon Bourgeois, Prior of the Great St. Bernard, took it into his learned head about twelve months ago that if telephone offices were organised at St. Remy, in the monastery itself, and at Proz en Valais, the number of fatal accidents annually happening among French and Italian workmen while crossing the mountains between October and May might be diminished. He communicated the idea to Canon Berard, of Aosta, who took up the matter with energy. M. Bourgeois had invented a telephonic apparatus of his own, and after a while the Swiss and Italian Governments gave their respective sanctions to the proposed plans. The Prior was duly authorised to join his telephone to the telegraph wire between Aosta and Martingy. Since then telephones have been in operation at La Thuile, in the Hospice of the Little St. Bernard, and in several adjacent cantons. Last Sunday the Canon had a kind of field-day with his telephones, and, making the Little St. Bernard his temporary headquarters, he conversed with the brother in charge of the office in the Hospice of the Grand St. Bernard and with the officials in the various cantons.

Gas v. Electricity.—A note appears in the last issue of the *Gas World*, which deserves attention. The papers devoted to gas interests never miss an opportunity of declaiming against electricity, and nothing seems to please them better than to chronicle a failure in electric lighting. The following is the note referred to :—Writing to us on the subject of gas and electric light, Messrs. Baxendale and Company, Manchester, say that some time ago Messrs. Hope Brothers, Ludgate Hill, London, opened an extensive branch establishment in the leading thoroughfare of Manchester. The nature of their business requiring a powerful outside light, they determined to fit up electric arc lamps the whole length of the building. This was done by one of the leading electric engineers in Manchester, but the uncertainty of the light and the loss of a man's time, who was kept constantly attending to the lamps, caused the firm to look out for a substitute which would require no attention, and which would yet give a powerful light." Gas replaced the arc lamps. Now we should be glad to have the electrical engineer's statement of his case. For our own part we are quite sure that there are half-a-dozen different arc lamps suitable for such work, that would burn quickly and effectively without the loss of "a mans time," except, of course, so far as the necessary trimming was concerned.

Electricity a Competitor with Gas.—The *Gas World* in its retrospect of 1887, admits that electricity is and will be a competitotor with gas for illuminating purposes. It says : "As the electric light does not appeal to the lower strata of society, and as it cannot be said to have any substantial claim upon the middle class, the advocates of that system of lighting must look for the greatest amount of support from the wealthy and aristocratic classes. And it is just in the houses of these people that gas is generally used. It will now be perceived that if the gas industry is to be injured, the injury must come from the adoption of the electric light in the better class of houses, places of public amusement, and restaurants, where hitherto gas has reigned supreme. It is clear, therefore, that the true competitor of gas—at least, for public and private illumination—is the arc and incandescent electric light. These systems have already supplanted gas at many large establishments in the metropolis and in the provinces. Some folks may think it is paradoxical to assert that the gas industry is advancing while the incandescent electric light is ousting it from these establishments. But it is the case, all the same. Recent years have seen the application of gas to a variety of purposes undreamt of by the pioneers of the industry. It is the fuel in many instances which drives the engines to keep up the supply of electricity ; it is used for domestic purposes, such as heating, cooking and washing."

Electric Light at Terni.—This installation of these works, says *Industries*, which has now been in use for about a year, has proved very successful. At first some difficulty was experienced with the arc lamps, which had a tendency to overfeed, owing to the vibration caused by the blows of the 100-ton hammer ; but some improvements have been made in the feeding mechanism, by which this difficulty has been successfully removed. An accident also happened a short time ago in the dynamo house, when one of the joints in the high-pressure supply mains gave way and flooded the room very quickly, doing some damage to the electrical machinery. With these exceptions, however, the installation has has worked without a hitch. There are about six miles of mains put up, chiefly copper wire, supported by porcelain insulators on poles. The lamps are divided into twelve circuits, which radiate in all directions from the clock tower surmounting the dynamo house, and each circuit is separately controlled by a switch. There are about one hundred Schwerd arc lamps of 2,000 c.p. each, and over three hundred Bernstein glow lamps of from 25 c.p. to 50 c.p. in use. The total area occupied by the steel works is 210,500 square yards. For external lighting, some fifty-six arc lamps illuminate an area of 160,000 square yards, being at the rate of one arc light for every 2,860 square yards, whilst for internal lighting there are forty-three arc lamps which illuminate an area of 31,500 square yards ; thus each lamp lights 730 square yards. The incandescent lamps are distributed over an area of 4,000 square yards.

New Year's Honours.—The *Evening Post*, discussing the honours announced with the new year, refers to that bestowed on Mr. John Pender in the following terms :— "Sir John Pender ! Long looked for, come at last. The ex-member for the Wick Burghs has found it easier to get a knighthood from a Conservative Government when he is out of Parliament than to be decorated by his own party when he was serving it by his votes. But the belief is that Sir John Pender, K.C.M.G., rated his services to the country at something higher than the second grade of a Colonial order." Whatever be the opinion of the *Evening Post*, whatever be our opinion of Mr. Pender personally, there can scarcely be two opinions as to the services he has rendered, in conjunction with his colleagues to this country, and we deliberately say that the distinction conferred upon him is unworthy of the country he has delighted to serve. It may be all very well to say, since his and his colleagues' policy has been successful, that any other man would have been just as successful. We deny it. The battle has been fought and won—any man can now rest on the battlefield and shout victory—but that is no proof of his being able to win a victory himself. To carry out a cable or any other system which has been constructed *ab initio*, and is now approaching completion, is not a hard task. The uphill work was in past years, and it matters little whether the ruling passion was self-interest—which is the case with most of us—the result is of immense importance to the country and to civilized humanity; and if it deserved recognition, it deserves

something of a far higher order and character than has been given.

Telephony in the United Kingdom.—A series of articles upon the Telephone Companies of the United Kingdom, which originally appeared in the *Weekly Bulletin* have been reprinted and issued in pamphlet form with an introduction by Mr. C. L. W. Fitzgerald. It may therefore be taken as almost an authoritative statement of the position of the telephone companies; and the remarks concerning the existing relations between these companies and the Government are worthy of attention. The most important paragraphs in this direction are at the end of the introduction and at the end of the reprint. Mr. Fitzgerald at the conclusion of his introduction says: "If a map were made of the different trunk wires already run by the various companies, it would be found that but little remained to be done beyond the running of trunk wires between London and Bristol and London and Birmingham to enable the principal commercial centres to converse together. Once this is done, the Postmaster-General will find a sharp competition spring up, against which he will find himself powerless." The concluding paragraph in the pamphlet reads thus:—"The brief description we have attempted during the last few weeks of the development of telephony all over the United Kingdom has far exceeded the limits we proposed to ourselves when we set out; but as we went on the conviction was forced upon us more and more that public opinion needed to be informed of the magnitude of the monopoly silently growing up in all directions, and for which every year's delay in State-purchase will add an increased burden to the country ultimately. There are a good many of our legislators who are only burning to find a cause in which they may distinguish themselves. We commend to them the serious study of the telephone problem. Judging by past experience, the Government will need a good deal of awakening before it rubs its eyes and realises the naked fact that every year the sum which it will eventually cost the country to secure the control of the telephone service, which means cheap telephony and universal telephony, such as private companies can obviously never give, is mounting up at the rate of millions a year. The estimated value of the parent and subsidiary companies is now five millions sterling, and in a very few years they will have reached a value of nearer twenty millions than five. We suppose, however, that the Government will wait till the provinces are all connected with London, and the companies amalgamated, and at a ruinous cost they will then begin to bestir themselves. Let us hope that in this case, at any rate, we may prove to be false prophets."

Gas Companies and Electric Lighting.—The action of the Bradford Corporation (the owners of the gas works), of the Imperial Continental Gas Association, of the town of Lubeck, of the authorities at Londonderry, Waterford, &c., should be carefully considered by all engaged in the electric light industry. It would seem that the natural development of electric lighting is that the installations should be carried out by local companies specially formed to supply illuminants. Some years ago the present writer suggested to the gas companies that the best policy they could pursue was to obtain powers to carry out electric lighting, not with any idea of never using those powers, but on the contrary, with the intention of pushing forward the work. Mr. King, from a paper read before the American Gaslight Association, seems to share these views. He says:—"I do not believe that electricity is to drive gas for illumination out of the field, and that we can be comforted by knowing that our existing plant is to be devoted exclusively to sending out a fuel. But I do believe there is a place for electricity; that we, as gas men, are the proper ones to supply it; and that the time is coming when it will be so considered by all. There is a good deal of philosophy in the reply of a certain gas man, who was asked if it were true that his company were going to enter the electrical field? He replied: 'Yes; and I should not be surprised if we were selling coal oil before long. We are in the light business.' So far, the competition of electric light has not seemed to diminish the use of gas to any extent; in fact, most companies report not only the average, but even a larger increase than usual in their send-out. But if the use of electricity continues to increase as it has in the last few years, will this always be true? In our section of country the arc light has almost superseded gas for street illumination. All buildings in course of construction of any size or importance in the various cities of the country are being wired for incandescent lighting. The report comes that all manufacturing establishments supplying electric lighting material are far behind their orders. Does all this mean that, after six or seven years use, it has been found unprofitable to engage in electric lighting, or that the demand is growing less? Undoubtedly there have been failures and unprofitable investments in this field; but has it been the rule? I certainly have heard of no gas company that has tried the experiment and failed." The reader of the paper thus goes on to explain the advantages a gas company has in carrying out the work. "Now, let us see what advantages the average gas company may have: (1) I would say on cost of installation, the probability is that all companies can find the small piece of ground necessary on the property they own, and maybe sufficient room in their present buildings, by re-arranging and economizing space. For necessary foundations, a grout—made of old retorts, old fire-bricks, and refuse of various kinds broken to the proper size—can be utilized with spent lime, which is almost as good as cement for this purpose. (2) The saving in expense of management cannot be questioned. That with the force necessarily a part of the gas plant fewer new men will be needed, must be apparent. (3) That gas companies have a certain amount of refuse, that would otherwise be waste, which can be used for fuel. For instance, coal dust, coke breeze, and more or less coke that can be secured by screening their cinders. All these we use on ordinary grate bars, with the help of a Parsons blower. If a furnace adapted more especially for this kind of fuel—say, something something on the plan of our regenerative or recuperative furnaces—were made to supply a battery of boilers, the expense for fuel might be reduced to a minimum. Burners for using oil and tar are also being perfected. Possibly when prices for tar are such as have obtained in many parts of the country during the last few years, it might be found profitable to make light of it. (4) who can realize the possibilities and the advantages that gas companies may have over all other competitors, when they shall be able to use for fuel, or directly in the engine, a gas that shall cost them but from 2 to 3 cents per 1000 cubic feet? This you know we are promised."

ELECTRICAL DISTRIBUTION BY TRANSFORMERS.

The great simplicity, low cost and high efficiency of the alternate current transformer are merits which have given this apparatus a dominant position in cases where electric energy has to be transmitted over long distances and distributed throughout a considerable area. It may be that the future will see a greater developement of storage batteries, a cheapening of these appliances and an increase in their present low efficiency, averaging as it does only about 60 per cent., whereby it will be possible to light a district from a central station and a large number of sub-centres containing storage batteries. In this case would be secured two advantages not possessed by the alternating current system. In the first place the current supplied would be suitable for motive power and electrolytic purposes, and in the second place the supply of energy would not be so directly and immediately dependent upon the maintaining of machinery constantly in motion at the central station. But notwithstanding these obvious advantages the use of batteries is at present practically excluded from cental station lighting owing to their high cost and low efficiency, whilst on the other hand the theoretically less perfect system of distribution by alternating currents and transformers is coming more and more into use. It is a significant fact that the utility of transformers is even recognised by those who may reasonably be supposed to have the greatest possible interest in the direct supply system. Thus the Thomson-Houston Company in America have added the Westinghouse alternate current system to their original business, and with the most satisfactory results; the New York Edison Company have bought the Zipernowsky patents for transformers in order to be able to extend their area of supply; the Milan Edison Company have had Ganz machines and Zipernowsky transformers at work for a year and a half, and other Continental Companies are following suit. A large central station on the alternate current system has been established at Rome, another at Lucerne, and smaller stations in various continental towns have become a matter of ordinary occurence. Here in England central station lighting has not been developed to anything like the extent prevailing in America or the Continent, but the only large central station, that in Bond Street, in London is on the alternate current system, and as our readers know, a similar station on a truly gigantic scale is projected for Deptford from which a great part of the City is to be supplied.

With these proofs of the vitality of the alternate current system before them, engineers need not hesitate to adopt it at once for central station work, notwithstanding the possibility that some better system might be devised in the future. Hesitation might be justified if there were any probability that an equally cheap continuous current system would be available within a short time, or if the change to the better system, when it becomes available, would involve the discarding of the whole of the alternate current plant. But there is as yet very little prospect that the first proposition will be realised; whilst, as regards the second, it is quite certain that the greater and more expensive part of the installation, viz., the motive power and the distributing plant, will be equally suitable for the continuous current system when the transition can be made. It might be objected that the present system of overhead primary wires as used in connection with transformers would be quite unsuitable for general distribution on the continuous current system. The answer is, that overhead wires are equally unsuitable for a general system of public supply by means of alternating currents and transformers. It is in this connection that the partisans of the alternate current system have hitherto made the mistake of generalising from isolated experiments. We remember that it was some years ago a favourite boast of one of the electricians on the staff of the original Company owning the Gaulard and Gibb's patents; that they could override the Electric Lighting Act by not making any use at all of the streets but simply stringing their primary mains overhead from posts fixed to the roofs of the houses, and therefore on private property, for which wayleave could always be obtained without troubling municipal or other authorities. As a matter of fact the whole of the distributing plant in connection with the Bond Street central station consists of such wires, and as this installation has attained a considerable size, it might seem as if the boast of the early pioneer above mentioned could indeed be realised in actual practice. But consider how the present state of things has come about. The Bond-street Station was started principally with the object of supplying the Grosvenor Gallery with light. The venture was a success, and induced other establishments to apply for current. Shopkeepers here and there, then private houses, some restaurants and cafes, and a few theatres and other places of entertainment became customers. It was so easy and simple to add new subscribers to the list. All that was required was to string a new pair, or tap one of the existing pairs of overhead mains, and connect those with a transformer installed on the premises of the new subscriber. Owing to the high pressure the current can be carried to a considerable distance, and thus there seems to be hardly any limit to extension. But this is not a general system of supply. As long as isolated points at considerable distances apart have to be supplied, the overhead system is probably the only one which can be used with economy, whilst the general and very natural objection of the inhabitants to overhead wires can be overcome by the plea that after all, in any given spot, there are but few of such wires erected. But, imagine what state of things would exist if every house in a district had to be supplied in this fashion. Wires would grow to the size of heavy cables, disfiguring our streets and forming an ever present danger. It is tolerably certain that amongst the many hundreds of mains which would cross our streets in all possible directions there would be some which are imperfectly secured or are otherwise defective, and would, from time to time, fall to the ground with disastrous results to life and property. But apart from considerations of safety, the system would be too costly. Mr. Preece recently told the Institution of Civil Engineers that the yearly upkeep of an overhead circuit costs about £7 per mile. With heavy cables the expense would probably be much greater, to say nothing of the damage which a snowstorm like that of last year might do to the system. In view of all this, the advocates of the alternate current system must make up their minds to adopt underground mains if they would hope to establish a system of supply which should be really general, and as it would be obviously too costly, and in a measure also dangerous to connect the transformer of each subscriber directly with underground mains in the same way as is now done with the overhead wires, we are forced to the conclusion that the distribution must be made by a network of low pressure underground mains, very much in the same manner, but not to the same extent, as the system at present in use where the lamps are directly supplied from the dynamos at the central station. We say, "not to the same extent," because the maximum distance from the source of current to the lamps could be considerably shortened. In the direct supply system, such as is used in New York, Berlin, Milan, and other towns, the source of current is necessarily concentrated at the central station, and although we may diminish the inequality of pressure at different points by the establishment of "feeding centres" each supplied with current at constant pressure by its own dynamo, there is obviously a limit to the number of feeding centres by the greater complexity of the plant at the central station, and by the necessity from economic reasons of employing dynamos of fairly large size. Each feeding centre must, therefore, supply a comparatively large number of lamps, and as a necessary consequence the distance between neighbouring feeding centres must be considerable, necessitating the employment of very heavy distributing mains. Now, if we can halve the distance between the feeding centres, we quarter the weight of copper in the mains, and it is in this connection that the great utility of the alternate current system, or for the matter of that, any transforming system becomes apparent. There is practically no limit to the number of feeding centres, or as they properly ought to be called, sub-centres, which can be installed. Owing to the high pressure in the primary circuit the feeding mains need not be large and yet the pressure at the sub-centres may be practically constant, notwithstanding any possible variation in the call for current at different times and in different sections of the district. It therefore becomes

possible to establish a great many more sub-centres as there are dynamos at the station, whilst the weight of copper in the distributing mains can be reduced to an amount which will render it possible to work the district with economy. But the present custom of placing a small transformer on the premises of each subscriber would have to be abandoned in a system of general supply. The installation would be somewhat as follows:—A network of underground distributing mains of comparatively small section and subscribers connections as in the usual direct supply systems. The network to be provided with a large number of feeding boxes containing the connections with the secondary terminals of large transformers placed as near these points as possible. The primary terminals of these transformers would be connected by "feeders" also preferably placed underground, with the generating station. The loss of pressure in these feeders need only be very trifling, say from 1 to 2 per cent. at the outside, and since large transformers can be made almost completely self-regulating, the variation in pressure at the lamps could be kept well within the limits now usual in installations supplied on the direct system. In this manner it would be possible to light a considerable district from a station, two, three or more miles distant, but it is evident that this is only possible because of the proper network of underground distributing mains. Now this network would be equally necessary had we assumed that the district would be lighted by continuous currents with the intervention of storage batteries. The only part of the plant that would in this case have to be changed would be the alternate current transformers for which storage batteries would have to be substituted. Otherwise the whole of the distributing plant, including feeders, feeding boxes, network, and house connections, would remain serviceable under the new system. As regards the generating station the only part to be changed would be the dynamos; all the rest, viz., boilers, engines, shafting and other gear, regulating appliances, and measuring instruments, would be equally available when a transition to a continuous current supply can be made. To recapitulate: Secondary batteries would form the most reliable agents for distributing electric currents, throughout large districts from a central station, provided they were sufficiently cheap and efficient. Until batteries are improved so as to be able to compete in point of cost, maintenance and efficiency with transformers, it is best to supply the district on the alternating current system, laying down such power and distributing plant as will be equally available when the transition to the more perfect system of lighting by batteries can be made.

The secondary terminals of these transformers would evidently have to be coupled in parallel to the network of distributing mains so as to ensure automatically that distribution of current which involves a minimum of energy lost by the resistance of the mains. A moment's consideration will show that the primary terminals would also have to be connected in parallel with the source of supply at the central station. In other words the transformers must be run in parallel from a network of high pressure feeding mains. The only other alternative is to run them in series on a single feeding circuit, but there are several objections to this plan. In the first place there is the difficulty of regulation, and this we fear is insurmountable. It is true that attempts have been made to obtain self-regulation in a series transformers by inserting a small induction coil in lieu of every lamp switched out, so as to maintain the total current traversing to secondary coil of the transformer constant and independent of the number of lamps alight. But this device cannot possibly ensure constancy of pressure in the secondary circuit for the simple reason, that that portion of the secondary current which passes through the lamps is nearly a quarter phase in advance over that portion of the secondary current which passes through the coils. Consequently the maximum magnetisation of the core of the transformer must even with a constant resultant secondary and an absolutely constant primary current alter for every individual combination of lamps and induction coils and as the pressure is very nearly proportional to this magnetisation it follows that the brillancy of the lamps cannot be a constant. This defect which is inherent in the series system might be overcome by the addition to each transformer of some regulating device to automatically vary the number of the active primary turns, but as such an apparatus would involve the employment of more or less delicate machinery for actuating a complicated system of switches, it might almost be considered as impracticable. In the next place there is the objection to the series system that any failure at a single point in the feeding circuit would put the whole of the area served by the central station into darkness. In the parallel system a breakdown of one transformer would on the other hand only have the result of lowering by a very few volts the pressure on the lamps nearest to this particular transformer, the other transformers to either side of it being able to supply the additional current required. Another objection to the series system is that the section of the wire in the primary coil becomes too great, and the wire becomes therefore liable to be traversed by eddy currents. It is evident that in a general scheme of supply it will not be safe to employ currents of higher electro-motive force than 2,000 or 3,000 volts. We have lately heard about a proposal to go up to 10,000 volts, but until actual practice has shown this to be possible and safe electrical engineers will scarcely care to work at so high a pressure. Taking 2,500 volts as a safe maximum of pressure, an installation for the supply of 20,000 glow lamps simultaneously alight would require a primary current of 500 amperes. The cross sectional area of the wire in the primary coil of the transformers would therefore have to be very large, probably half a square inch, and with so large a section eddy currents would be almost inevitable. With parallel transformers no such difficulty would arise. The transformers would be fairly large, say from 500 to 1,000 lights, they would be practically self-regulating, and requiring no attention could be placed in underground localities for which a very moderate rent only need be paid. When storage batteries have become sufficiently improved they could be installed in lieu of the transformers and the transition to the more perfect system of a general supply of current for lighting, power and chemical purposes could be effected at a very moderate additional outlay. We have in the foregoing brief sketch necessarily omitted to consider many questions of detail, as a thorough consideration of the points involved would be far be beyond the limits at our disposal. We have endeavoured to lay before our readers what may be described as the fundamental principles of distribution rather than a scheme worked out in all its details, but enough has probably been said to show that the means which are at present at the disposal of the electrical engineer enable him to lay down a system for the public supply of electricity for lighting purposes which will be safe, efficient and economical.

BUSINESS METHODS.

Complaints are frequently made by the trade that electrical Engineering does not progress so fast as, in the opinion of those engaged in it, it should. Various reasons are given for this. Now, it is the Electric Lighting Act which discourages enterprise. Then, it is the holders of some electrical monopoly, who imagine that the experience of the rest of the business world is to be reversed in their favour, and that the whole body of consumers are to fall down and worship, or come and be taxed as the monopolists may decree; other causes, no doubt will have been mentioned in the hearing of readers of this journal; but it is doubtful if one cause, which is probably more powerful for evil than any other—is ever mentioned, viz.— the method of carrying on their business adopted by many of those engaged in electrical industries. While quite able to see the folly of short-sighted monopolists, many of those engaged in the manufacture, the sale, or the installation of electrical apparatus appear to assume just as great an inversion of the laws upon which business is usually transacted as do those upon whom they sit in judgment. They constantly act as though they expected the miracle Mahomet promised to his followers, to be performed for their benefit; and they have not Mahomet's sense, in too many instances, to go to the mountain when they find it will not come to them. In other words, they are constantly

expecting that in place of adapting their apparatus as closely as possible to the requirements of society as at present constituted, and gradually educating society up to a higher standard and a higher appreciation of their apparatus, society is to shut it's eyes and open it's mouth to see what a good fairy will send.

If they fix apparatus, in a great many instances they carefully withold all information as to its construction, regulation, &c., from the users. If they are sellers of apparatus only, they expect the whole profit that can possibly be made on the transaction—that is to say, the whole difference between manufacturing cost and selling price; and they do not expect to assume any responsibility, to have any trouble, or to take any pains to make an apparatus go right. In many cases they do not know how to. It may be the tightening of a screw, the connection of a wire, the repairing of some one of those trivial slips that are constantly occurring and will always occur in manufacturing until a superior order of beings take to the work; and the maker may be hundreds of miles away, nevertheless, he or his representative has to come at the bidding of the seller, often at a heavy expense, to perform some trifling operation which, if it occurred in any other branch of engineering, would be cheerfully and promptly done by the user; and the reward for all this is a future profit, which from the nature of things, can hardly ever be realised. Or it may be that the installer himself has made a trifling error, as installers even will do *occasionally*, or something has occurred to some other part of the apparatus, producing results that he does not understand, and he promptly lays it at the door of some part of the apparatus that he has purchased, and that he likewise does not understand, having arrived at the cause by the simple process of reasoning adopted by the little boy who wished his grandmother dead, but who did not wish to say so straight out. It is not this and it is not that—at least, the installer *believes not*; it cannot be the other, because it is his own design; therefore, it must be that other apparatus that he bought from so-and-so; and, for their own credit, they had better send someone to see about it. It would be much better for them to spend a little money now than lose future orders.

And then if a firm happens to do business anywhere in the provinces; getting, as they usually do, a thorough business training if they hold on long enough; their experience with many firms who wish to supply their wants, or to whom they have to look for different apparatus that they use, are somewhat exasperating. They are usually inundated with circulars, often with beautifully illustrated catalogues, and occasionally honoured by the visit of a traveller.

In the course of their business they are perhaps requested to prepare an estimate for certain work for someone in their district to whom they are well known. They are perhaps entrusted with a contract to supply and fix certain apparatus, in which may be included some of the beautiful designs in the catalogues that have been showered on them. They place their orders for the different apparatus they require with the different makers. So long as these are outside the boundary of electrical engineering pure and simple they have no trouble. Orders are acknowledged, and the goods forwarded in due course. But immediately their requirements come inside the magic line, it is another matter altogether. The order remains unnoticed perhaps for days. Soon they write to know when they may expect the goods, as they want to start the installation. No reply. They write again, asking for a reply to their former letter. Still no reply. They telegraph. No reply. They telegraph and pay for a reply. Occasionally this produces some effect. They perhaps receive a reply that the order is in hand. Sometimes they are asked to refer to their order and the matter shall be attended to. Sometimes they get no reply at all. Meanwhile work is going on, and cannot be left. Perhaps a postcard is sent, and not unfrequently receives more attention than all the letters and telegrams.

Next contract, another firm is tried, sometimes with temporarily better results. Often a sample order for stores required in the lighting season is delivered in the following summer. In some cases an enquiry is booked as an order, though if it was made firm there would be the same difficulty in obtaining delivery as before. Not infrequently samples of certain goods are sent, and, when the order is completed, the bulk are quite different. An order will be accepted conditional on delivery within say seven or ten days, but no effort is made to complete in less than three weeks, no matter what the conditions, and then it is considered sharp.

And as to how all this effects the trade. It must be remembered that all these delays cost money, and that in preparing his next estimate, the provincial engineer adds to his quantities a sum that will cover this extra expense, and reckons his profit on the gross total; so that in place of prices falling as they should do, with the progress that is constantly being made, the legitimate fall is seriously retarded without anyone benefitting, and with the result that fewer contracts are given out. Those who wait until prices reach a certain figure, go on waiting a little longer, whereas but for this unnecessary increased cost, many of them would have placed their orders. Or perhaps the provincial resolves to take the bull by the horns and make the apparatus himself in his own workshop, and so is gradually developed a rival who in course of time may not be satisfied with supplying his own wants. In any case trade is lost to those whe held it before.

Another very reprehensible plan is that, adopted by many makers of apparatus, of giving to consumers the same terms as to the trade. A manufacturer has, say, a speciality upon which he allows a certain profit to the trade for selling. An installer, or a firm who make it their business to retail apparatus, bring this speciality under the notice of some clients of theirs and procure orders. By-and-bye, one of their clients, being perhaps interested in the science, takes up an electrical paper, sees the speciality advertised, writes to the advertiser, and in many cases receives a quotation at exactly the same figure as that at which the maker supplies to the trade; amongst them the firm from whom the enquirer has previously bought. The result is that the enquirer, if he be engaged in business, not understanding such an arrangement, comes to the conclusion that the firm he purchased from have been making an extravagant profit. That is to say, he takes it that their profit is measured, not by the discount the manufacturer has offered to allow him, less perhaps two carriages, packing, &c.; nothing will make him believe that, but by that, plus another trade discount, and he forthwwith looks with considerable suspicion upon all transactions for some time to come.

There can be very little doubt that this proceeding on the part of the manufacturer is both morally and commercially wrong.

The local sellers have in some form or other expended time and money in placing the particular speciality before their friends; and they have done it on the implied understanding that rules in all other cases, that they will be protected by the manufacturer from the consequences of an accident such as that described, by the simple straightforward plan of quoting, to customers, customer's prices.

A man building a house for himself, unless he be a builder, will not be able to buy his bricks and mortar at builder's prices, no matter how big a man he may be in other respects. He may get a discount for quantity if he purchases a large quantity, or for cash if he pays cash; but these will be special discounts, and will represent a portion of the extra profit that the purchase of the large quantity or the cash payment enables the seller to make. A trade buyer would get the same discounts in addition to the regular selling profit.

And the result to the manufacturer is to throw his former client into the hands of one of his rivals, so that, though he has possibly gained one customer, at no greater profit than before, he has lost the whole of his late client's connection; and he has converted him with all his local knowledge and influence into an enemy.

The above remarks are, of course, only intended to apply to those firms who carry on business on the lines indicated. There are, fortunately, many good electrical firms who conduct their business on sound business principles, with the usual result that success attends their labours, and that they go on extending year after year. On the other hand, there can be no doubt that business carried in the above

manner, affects even them in a small degree by causing outsiders to lose confidence in electrical engineering.

CONTINUOUS CURRENT TRANSFORMERS.

From one point of view the electrical engineer may take comfort to himself and rightly imagine that since '81 he may claim his work to be a great success, writ large; from another point of view this success may be questioned, and many quiet thinkers are inclined to spell success with an f. The truth is that we who live in these rapidly moving times are scarcely able to judge the exact position of things. If excelsior is the watchword, who is to decide when the top of the mountain is reached. Every inventor is so enamoured of his own litttle child, that he fancies perfection is attained and nothing more is left for future workers. When Gaulard and Gibbs first introduced the transformer system into commercial circles, they met with scant praise. yet within a few years transformers have forced themselves into the front, and seem destined to be largely employed. Hitherto the majority of inventors, or rather patentees, have devoted their energies to alternate current transformers, but the defects are many, and the conveniences of a continuous current so great that attention has necessarily been directed to the designs of such machines. Several alternate current transformers are in the market, but, so far as we know, only one continuous current transformer, that which we now illustrate.

The continuous current transformer of Paris and Scott, consists simply of an armature, with two sets of conductors and two accumulators, revolving in a constant field, the field magnets being excited from the low tension circuit. The ratio of the number of turns in the one conductor on the armature to that of the other, is the ratio between the E.M.F. of the primary and secondary circuits. In working, the primary is the motor circuit, and the secondary, the generator circuit; and, as the current in one circuit is in opposite direction to that in the other, the effects of self-induction, Foucault currents due to the current in the armature and lead of brushes are neutralised, the one by the other.

The transfomer exhibited at the late Newcastle Exhibition was a small one, being tested with an output of only 4 units, when only 3 per cent. of this was found to to be required for driving, thus showing conversion efficiency of 97 per cent., the commercial efficiency came out at 86 per cent., the speed at 200. Improvements have been made in more recent machines; so that now, by running at a slightly higher speed, the electrical loss in large transformers, such as would be used in practice, is reduced to under 4 per cent.; and as the power absorbed in driving a large transformer would naturally form a smaller percentage than in a smaller one, a commercial efficiency of 94 per cent. can be confidently expected. "As there is some misconception as to what is the natural domain of the continuous current transformers, one of your contemporaries having just published a comparison between the cost of distribution; fiirst, by accumulators; second, by continuous current transformers; and third, by alternate current transformers, we (Paris and Scott) take the opportunity of giving a sketch of what we believe to be the field and method of using continuous current transformers.

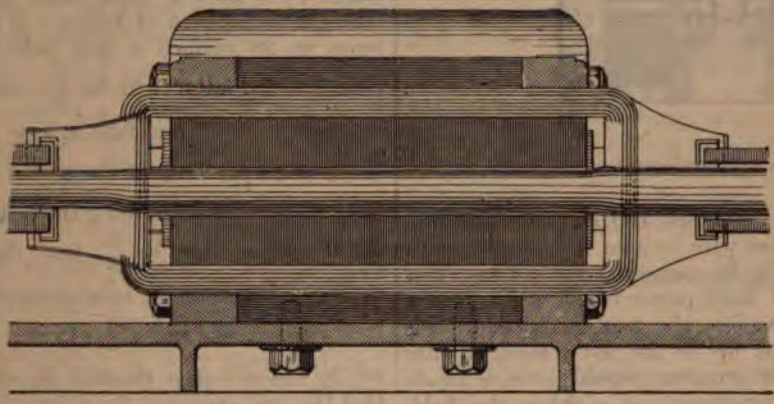


Fig. 1.—Section of Transformer.

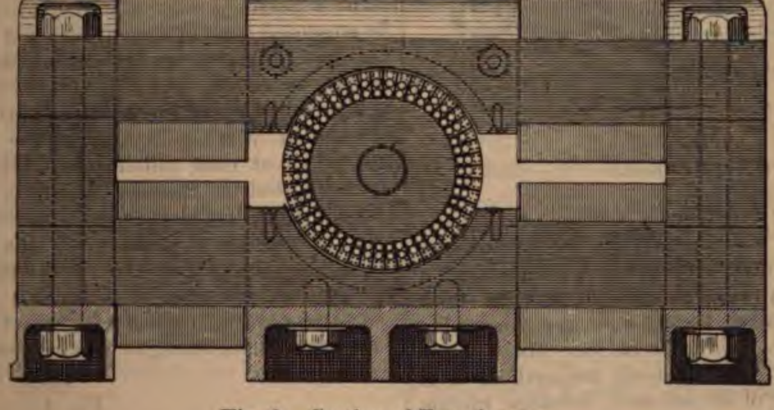


Fig. 2.—Section of Transformer.

One of their most important advantages over alternate current transformers is that they can be used in connection with accumulators. Another great advantage, that motive power can be distributed from the same central station, will come out in what follows by using a 600 volt high tension E.M.F. on the three wire system, and for lighting and small power, and transforming this into 100 volts, having accumulators in parallal with the lamps, these would discharge when the maximum output was required, and be charged

when the demand was at at a maximum, thus reducing the capital required for motive power, &c., at the central station. The advantages of having accumulators are so obvious that we need not recapitulate them. Not the least is that because of their admirable regulating qualities it is possible to take motive power from the same system that supplies light. Although motive power distribution by electricity has made little headway in England so far, yet we believe that in certain districts it will become before long more important and profitable than the lighting.

It is quite impracticable to distribute power up to 20 or

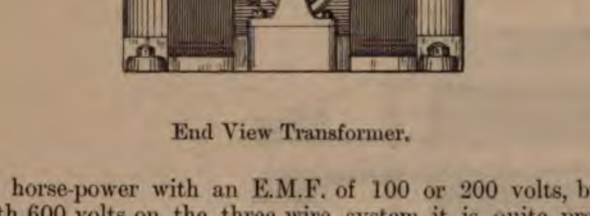
Fig. 3.

End View Transformer.

30 horse-power with an E.M.F. of 100 or 200 volts, but with 600 volts on the three wire system it is quite practicable, large motors might be connected up between the two outer wires, when 35 horse-power would only require a No. 8 wire. Where possible, the field magnets of the motor would be connected up to the low tension circuit, and where not the motor armature would have a small secondary circuit and commutator for exciting the field magnets. The motor would then run at practically a censtant speed without any regulating appliances, they would require veay little room and attention, and for this reason, even if the cost of electrical power came the same as power from gas or a steam engine, there would be few who would hesitate between them. The question is, can power be supplied as cheap or cheaper by electricity than it is obtained at present? Without going into figures the following figures will enable your readers to form an opinion for themselves.

It is acknowledged that for continuous work, except for small powers, a steam engine is cheaper and more satisfactory than a gas engine. Now, steam engines up to 20

Fig. 4.



Side View Transformer.

or 30 horse-power, as they are usually worked, take from three to four times, and often more, as much coal per horse-power as the large and well-managed engines in a central station would require, besides which they each require a man to look after them, and a considerable quantity of oil, waste, &c., which items per horse-power would, in a central station, be immensely reduced, so it is plain that, even with a loss of 30 per cent. between engine at the central station and the work to be done, power could be supplied at the same or less than it costs at present, leaving large margin for interest, &c., and profit, one very important point in the starting of an enterprise.

By thus combining the distribution of motive power with lighting from one central station the financial aspect of the whole affair is greatly altered for the better, for instead of the expensive machinery being only employed at its maximum for a few hours in the day, and for many hours doing very little or nothing, it is kept employed near its maximum for many hours, and by using accumulators almost continuously."

MAGNETIC INDUCTION, PERMEABILITY, AND SUSCEPTIBILITY.

BY E. C. RIMINGTON.

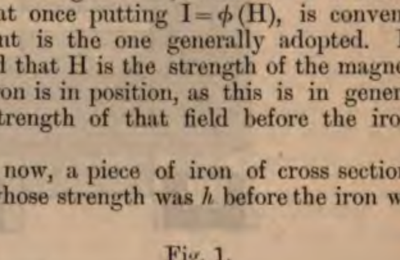
The definition of strength of magnetic field best conforming to the mathematical treatment of magnetism is: "Strength of field is measured by the force with which unit pole is acted on when placed in that field." In treating magnetism from the more practical side, *e.g.*, dynamo design, a more convenient definition is found to be "the number of lines of force passing through unit area measured on a surface normal to them;" or, if the field be not uniform, "the number of lines passing through an infinitely small area measured on an equipotential surface divided by the area." In order to make these two definitions agree, it is necessary to assume that a magnetic pole of strength m emits $4\pi m$ lines of force thus: Suppose round a pole of strength m a sphere of radius r to be described, and at any point on its surface a unit pole to be placed, the force acting in the latter will be $\frac{m}{r^2}$; hence, by the first definition, the strength of field at any point on the surface of the sphere is $\frac{m}{r^2}$; and, by the second definition, it follows that the number of lines passing through unit area of the surface of the sphere must be $\frac{m}{r^2}$, but the surface of a sphere $=4\pi r^2$. Therefore, the total number of lines passing through the surface $=4\pi r^2 \times \frac{m}{r^2} = 4\pi m$. Now, all the lines given out by the pole pass through the surface of the sphere, so that the pole gives out $4\pi m$ lines of force.

If a piece of iron be put into a magnetic field so that the lines of force pass through it, it becomes magnetised by induction and exhibits magnetic polarity. Its intensity of magnetisation is naturally defined to be its magnetic moment per unit volume, or $I=\frac{M}{V}$, where I is the intensity of magnetisation, M the magnetic moment, and V the volume. If the cross-section of the iron is constant throughout its length, the latter being measured in the direction of magnetisation, and we assume its poles to exist at its ends $I=\frac{m\,l}{A\,l}=\frac{m}{A}$ (A being the cross section), or $m=IA$, m being strength of pole, or, more correctly, strength of polar surface, as the poles cannot here be regarded as points.

If the strength of field in which the iron is placed be denoted by H, I is said to equal kH, where k is known as the "magnetic susceptibility" of the iron. k is not a constant depending only on the quality of the iron, as might be supposed, but is also a function of H, for weak fields; however, when the iron is nowhere near saturation, k is more or less constant, but depends to a certain extent on the previous history of the iron as regards magnetisation. This system of writing $I=kH$, where k is a function of H, instead of at once putting $I=\phi(H)$, is conventional and artificial, but is the one generally adopted. It must be remembered that H is the strength of the magnetising field when the iron is in position, as this is in general different from the strength of that field before the iron is placed in it.

Suppose, now, a piece of iron of cross section A placed in a field, whose strength was h before the iron was put into

Fig. 1.



it; let the intensity of magnetisation induced in the iron be I, its polar strength will be IA. Hence, $4\pi IA$ lines of force are emitted from the north-pole and pass, through

surrounding space, to the south-pole; these we will call external lines. Now, some of the surrounding space is occupied by the iron; let us suppose that n out of the $4\pi IA$ lines pass through the latter, this leaves $4\pi IA - n$ passing otherwise as in diagram. As every line of force is a closed curve passing externally from N to S and internally from S to N, the number of internal lines of force is $4\pi IA$, and these all pass through the substance of the iron from S to N. The total number of lines of force passing through the metal is thus: n external lines, $4\pi IA$ internal lines (these all being due to the iron acting as a magnet), and hA lines due to the original field. These three systems of lines added vectorially give the resultant system, which is called the "total magnetic induction" in the iron. Suppose, for simplicity, that the directions of the three systems within the iron are parallel, then the total induction $= 4\pi IA - n + hA$.

The "magnetic induction" or $\mathfrak{B}$ is the number of lines due to every cause within the iron per unit area, or

$$\mathfrak{B} = 4\pi I + \left(h - \frac{n}{A}\right) = 4\pi I + H.$$

H being the magnetising field which is less than h the original field by an amount $\frac{n}{A}$, this is due to the reaction of the poles on the field, and will be greater for a short, thick piece of iron than a long, thin one; if the length is infinite compared to the thickness $\frac{n}{A}$ will vanish and $H = h$; the same is true for an iron ring when the exciting field is due to a wrapping of wire conveying a current and completely surrounding it, since there will be no polarity. Since $I = kH$, $\mathfrak{B} = (4\pi k + 1)\ H = \mu H$, where μ is known as the "magnetic permeability." Hence $\mu = 4\pi k + 1$.

ELECTRIC LAMPS IN MINES.

BY J. W. SWAN.

Among the electrical memorabilia of the year 1887, the introduction of portable electric safety lamps for the regular lighting of coal mines ought to find a place.

It is long since the idea was proposed of applying electricity to the lighting of coal mines, but it is only since the incandescent lamp was perfected, and made on a miniature scale, that the idea became practically realisable. It was barely realisable even then, for a good deal of experimenting had to be gone through before the battery, necessary for supplying the power to light the lamp, was put in a practical form. Now, all the difficuties in connection both with the lamp and the battery have been overcome, and the portable electric safety lamp is in every actual-day use, to the number of over two thousand, in some of the most fiery mines in the kingdom. So far the result has been very satisfactory. Miners greatly prefer the new to the old ones, and this is not wonderful, when it is remembered that the electric lamps give four times the light of the displaced oil lamps. It is needless to say that there has been no explosion caused by the electric lamps; indeed, it is difficult to imagine how such an accident could possibly occur, for every point has been most carefully guarded—the battery terminals are inaccessible to the workman carrying the lamp, and the lamps themselves are thoroughly defended against injury.

The use of electric lamps instead of oil lamps in coal mines calls for new means in detecting the presence of fire-damp; for, of course, the electric lamp is unaffected by it. The old safety lamp did, to a certain extent, indicate the presence of fire-damp, but it did not indicate it soon enough; the air was already in a dangerous condition before the Davy lamp gave any sign, so that, independenly of the new circumstances arising out of the substitution of electric lamps for oil lamps, a better and more sensitive indicator was urgently required. Fortunately, the electric safety lamp carries with it the power which enables this want to be met in an effectual way.

The idea of utilising the fact that a red hot platinum wire glows more brightly in a mixture of air and fire-damp than in pure air, is due to Mr. Liveing, and he has worked out the idea very thoroughly, insomuch that by means of his apparatus (which comprises the wires to be heated—a miniature photometer, and a small magneto-electric machine), comparatively accurate estimates may be made of the proportion of fire-damp present in air contaminated with it, down to so small a proportion of fire-damp as one volume in two hundred volumes of air.

The battery attached to the miner's electric lamp provides a ready means of heating platinum wire red hot, and by limiting the object of the test to *detection* without measurement, an exceedingly simple and small appendage to the electric safety lamp gives, on the principle described, even a greater power of detecting fire-damp than was possessed by the most sensitive of the oil safety lamps.

With a provision as that described for the detection of fire-damp, the electric safety lamp is not only safe in itself, but a means of safety by giving warning in the event of a dangerous accumulation of fire-damp occuring.

There is reason, therefore, to hope that the application of electricity to the lighting of mines, by means of portable lamps, an event belonging to 1887, will, by removing one of the causes of explosions, and by giving more light, tend to diminish the loss of life which unhappily attends the dangerous, but indispensable industry of coal mining.

Electric Clubs in America.—The electric club idea has evidently "caught on" in the States. Cincinnati is now about to follow in the footsteps of Boston, Chicago, and New York, and form a club of its own, where electrical men may forget trade rivalry and professional jealousies in the pleasures of social intercourse.

Curious Electrolytic Action.—No current meter as yet has found great favour with the profession on this side the water, but the Edison meter is extensively used in America. In a report by Mr. J. W. Hill to General Hickenlooper on the electric lighting of the central station at Chicago, reference is made to a curious action of these meters, about which, however, we should like a little more information. During the weighing of the zinc plates of the voltmeters used by the Electric Light Company to measure the amount of light furnished to the Depôt Company, the phenomenon—which, I am informed, is not infrequent—was developed of the diminishing plate gaining instead of losing (as it should if the meter is working properly) in weight, showing an apparent reversal of current for certain meters. The custom in cases of this kind being (as I am informed) to take the gain in weight of the plates—which should have lost in weight—as the measure of zinc transferred. Although authorities on electrical science assert that, with a given strength of current, the rate of transfer of zinc from one plate to another in a voltmeter is constant for any given time, and knowing the time and current the loss of zinc by the positive plate may be calculated from constants determined by experiment, it seems strange that the current should be reversed, as it was in the meters noted above. And this fact, of which we have ocular evidence, would indicate a state of affairs very dangerous to the pocket of the consumer of light, for if these meters will work backwards (as it were), why should they not work forwards at a rate greater than that assigned by theory, and cause a registration of more light than it actually furnished? If I were a consumer of electric light, I should require better evidence than that before me now to induce me to accept the record of these meters as a reliable statement of the light furnished."

THE

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TO OUR READERS.

To-day this journal, which has hitherto gone through a somewhat chequered career, appears in a manner more befitted to the requirements of the times. In future it will be published each week. An effort has been made in this number to indicate the policy the paper will pursue, but just as it is impossible for the grocer or the draper to show all the good things in the window, so we are unable to do more than indicate the various matters which are intended to be discussed in our pages. The tendency of the recent developments of electricity has been to prove that in its practical applications it must rank as a branch of engineering. In future an engineer, while possessing a general grasp of the whole subject of engineering, will have to specially qualify in one particular branch. Here indeed comes into force once more Lord Brougham's dictum, which in a modified form as applicable to engineers might read—the best educated engineer is "he who knows a little about all its branches and everything about one branch." While therefore devoting our pages specially to the subject of electrical engineering, we shall not neglect those subjects which have an indirect interest to the profession. Just as in other branches of the great engineering profession, we find electrical engineers are by the ordinary laws governing labour, gradually becoming classified into the grades of "Consulting," "Superintending or In Charge," "Manufacturing," and, the largest class "the workers." At present there is no broad line of demarcation between the various classes, but the time is fast coming when the distinctions will be more widely recognised. We trust that our pages will contain information necessary to each and all these branches of the profession.

The articles which appear in this number must be taken to indicate the drift of our policy, for we do not intend otherwise to lift the veil that the curious may see. Let us rather now consider the present position of electrical engineering. So far as electric lighting is concerned it is by no means new to the scientific public. From the beginning of the century the "arc" has been the wonder shown at all lectures on physics. In the forties for a time there was a boom in electric lighting almost as intense as that in eighty-two, but it died away because the embryonic dynamo could not take the place of primary batteries, and the latter were ill-adapted for the work required of them. In the fifties Wildes machine, and subsequently the Alliance machine, enabled the electric light to be used in a few lighthouses; but it was not till Gramme and Siemens gave to the world improved dynamos, that electric lighting was commercially practicable. The late Count du Moncel, the friend and the guide of the writer to the Paris International Exhibition of 1878, was enraptured with the development of electric lighting as shown by Jablochkoff; but it was reserved for the Paris Exhibition of 1881 to set the public mind in a blaze as to the possibilities of the new light. France, America, and a great part of England then lost their heads—the people lost their money, and electrical engineering in the broadest sense was started. Since 1881 the whirligig of change has been rapid, till now at the beginning of 1888, the certainty of what will constitute the feature of the immediate future is unsettled We incline to the opinion that distribution by means of transformers will be tried on a large scale, and we believe that both alternate current and direct current transformers will be used. Whether transformers will ultimately give place to secondary batteries is a problem that time alone can solve. Certain it is that while there is an enormous field for the secondary batteries now in the market, great improvements must be made upon them before

they can economically compete with transformers in central station work.

Another branch of electrical engineering which promises immediate and great development is in the transmission of energy. It is true that electricians must learn to know the meaning of such words as "expedient," "convenient," &c. It is foolish to attempt to convert a user of power from steam to electricity when the former is as convenient as the latter. No matter how perfect the dynamo and motor, it stands to reason that one loss is better than three.

The present position then is, that we are in the initial stages of an enormous industry. The applications of electricity are so numerous that its possibilities seem almost infinite, and we intend from week to week to do our best to make our readers acquainted with those processes and constructions which seem to stand in the van of progress.

EDWARD GRAVES, ESQ.

President Institution of Electrical Engineers.

We have much pleasure in presenting to our prospective readers, with the first issue of *The Electrical Engineer* as a weekly paper, a portrait and a *fac simile* of the signature of the Engineer-in-Chief of the Post Office Telegraphs, who has recently been elected President of the Society of Telegraph-Engineers and Electricians—hereafter to be known, we believe, as the Institution of Electrical Engineers. This Society, for the last ten years, has had reason to appreciate the services of Mr. Graves in the capacity of its Treasurer; and the thirty-five years of practical acquaintance with electro-telegraphy to which that gentleman may lay claim constitute strong additional grounds for the honour they have sought to confer upon him. Mr. Graves represents the financial rather than the scientific side of electrical engineering; and it may here be pointed out that to him the country is mainly indebted for the reduction, to the extent of some millions sterling, of the compensation claims put forward by the various Railway Companies under the Telegraph Act. A glance at the list of the Past-Presidents of the above-mentioned Society will show that science can well afford a recognition of the claims of business industry and financial ability in the person of the actual President.

Mr. Edward Graves was born in 1834; and, as we have said, became first connected with telegraphy thirty-five years ago, when he entered the service o the Electric and International Telegraph Company. In 1856 he was appointed Superintendent and District Engineer of that Company's Northern District. It is not generally known that, from 1859 to 1863, Mr. Graves was a frequent and successful lecturer to popular audiences—greatly to the advantage of certain deserving charities. In 1870, the period of the transfer of the Telegraphs to the State—in which he was engaged in the conduct of many of the chief arbitration cases—he was removed to Birmingham as Divisional Engineer in charge of the North-Western Division of Postal Telegraphs; and in 1878, on the retirement of Mr. R. S. Culley, he was appointed Engineer-in-Chief of the Post Office Telegraphs.

Mr. Graves represented the Post Office as delegate at the Paris Electrical Conference in 1881, when he received the Cross of Officer of the Legion of Honour from the French Government. He also served on the Channel Tunnel Defence Committee of 1882, and was a delegate to the Electrical Unit Conference at Paris in 1883.

GOVERNMENT AID TO TECHNICAL EDUCATION.

BY PROF. W. GARNETT.

Invited to furnish a short essay on the most striking object which has recently come under my notice, I was for some time in doubt what to write about, but during a few hours spent in London my doubts were dispelled; for, at the Apprenticeship Exhibition at the People's Palace, I saw what appeared to me to be more important from some points of view than any of the grand exhibits recently displayed in our numerous great exhibitions. I do not refer to the system of electric lighting there employed, nor, indeed, to anything of special interest to electricians, except, in so far as electricians and members of the medical profession must be interested, more, perhaps, than any other class of professional men in the work of scientific and technical colleges and institutes, for there are probably no other professions whose members owe so much to such institutions. The exhibit to which I refer is that of the work done by students of the Polytechnic Institution, and everyone interested in the education of artisans would do well not only to thoroughly study this exhibit, but to learn all that can be learned respecting the conduct of the Polytechnic classes, and the means by which such striking results have been brought about. A Bill for providing elementary technical education is to be brought before the House of Commons next session, and this time there is to be no power of veto given to the ratepayers as in the Bill of last session. It is worth considering whether the foundation in each district of an institution of the Polytechnic type would not prove a far more efficient means of developing technical skill in the country than the addition of workshops to board schools, and the placing of technical education in the hands of school boards and their elementary teachers under the superintendence of the Science and Art Department.

The Polytechnic Institution, or Young Men's Christian Institute, was purchased and equipped by Mr. Quintin Hogg some six or seven years ago, and has been carried on solely at his expense. Its membership is so far restricted that 80 per cent. at least of its members must be artisans. To gain any idea of the provision made for the recreation, education, and, we may add, religious instruction, of the members and students the reader must visit the institution and see everything for himself. No less than 6,000 young men are at present profiting by Mr. Quintin Hogg's liberality, and of these 4,000 are attending classes of one sort or an other.

The annual cost is a little over £6,000, so that the advantages of the establishment are afforded at a cost only slightly exceeding £1 per head per annum. Of course the workshop classes cost a very great deal more than those in which the teacher requires only black-board and chalk, with, perhaps, a few diagrams, or even those in which chemical apparatus and reagents, or optical or electrical instruments have to be employed for purposes of demonstration, and it is clear that apprentices could not be taught to carry out such work as that exhibited at the People's Palace at anything like the cost above mentioned, but the whole expense of the workshop classes is included in the

average of £1 per head, and there is scarcely any comparison to be made between the cost of the technical teaching provided in Regent-street, and that at which the work is done by some Continental schools which have recently been highly praised.

Technical education is at present a phrase to conjure with. The Government has made up its mind to do something to encourage and support it. Those who have the control of public and corporate funds are seeking how they can best employ them in promoting it. Private munificence is ready to endow it while literary and purely scientific education is placed for the time in the background. Notwithstanding this eagerness it is scarcely possible to find three persons casually brought together who will agree respecting what technical education should be, and what it is that should be thus endowed. In fact different trades have very different requirements, and even the same trade will require great diversity in its mode of treatment in different parts of the country. This makes it very difficult for any Government department to provide a scheme of technical education applicable to the whole country unless great latitude is given for its adaptation to the requirements of the various trades in different localities. For example, at a meeting of master plumbers held in the north of England the question was raised whether workshop practice should be part of the school curriculum for apprentices. or whether the training afforded in the workshops was sufficient. One master explained that, owing to the peculiarity of his business, many of his apprentices spent their time in "burning lead" in sulphuric acid chambers and had no opportunity of learning other branches of the trade. The business of another lay almost entirely in connection with domestic work and his apprentices had little opportuity of learning to make burnt joints. The result was a unanimous vote from the trade in favour of providing a workshop and practical instruction in all branches for the members of the technical classes. This, then, was the decision of the trade in that district, and it must be supposed that the master plumbers knew more of the requirements of their apprentices and the shortcomings of their own establishments than any College Council or Government Department could possibly know. Of course it was arranged to supplement the workshop practice by lectures and classes on arithmetic and mensuration, mechanics, the elements of physics and chemistry, including the effects of heat and cold on metals and water, and the chemistry of iron, lead, tin, zinc, copper, white lead, red lead, &c., the action of fluxes in soldering, the elements of hygiene, and principles of sanitation. In the same district the almost unanimous opinion of engineers (masters, foremen and draughtsmen) is, that technical training for their apprentices should, in the schools, be limited to laboratory work, and to the scientific basis of engineering (mathematics, mechanics, physics, chemistry, metallurgy, &c.), including, however, mechanical drawing, while for advanced students the laboratory work should comprise the testing of materials and experiments with steam engines and boilers, but the teaching of the use of tools should be absolutely confined to the worker, the technical school or college being provided with such tools only as are necessary for the work of the laboratory or the equipment of the museum and lecture room. They consider that in manual training the discipline of the workshop is of paramount importance, and there is much to be said for this view, although the extreme specialization which now takes place in very large works tends to develope, from the ordinary apprentice, men who can take charge of one tool and of one tool only. The writer met with a man out of employment a few days ago who had been for some years in a very large works, and was part of a drilling machine. There was no other machine in the works that he knew anything about.

It appears then, that as soon as we approach the teaching of specific trades, if we are to secure the confidence and support of masters and men, we must allow each trade in each district to decide for itself how its technical classes are to be conducted. In fact the workshop at the technical school will have simply to supply the deficiencies of trade workshops where such deficiencies exist, and under these circumstances it is not unreasonable to expect that where the trade of a district determines that workshop teaching should be provided to make up for the imperfect training afforded to apprentices in the works, the trade will find the means of conducting such workshop classes, and thus prevent local or imperial funds being employed for the benefit of one particular trade in preference to another. The whole question of workshop practice is a trade question simply, for where trades unions are strong, it is useless to think of teaching trades to outsiders unless we are prepared to receive outsiders only into the classes. The remarks respecting the maintenance of workshops in technical schools apply equally to lectures and classes bearing upon the technical details of specific trades. Such teaching should be supported either by the particular trades, or by local charities, or corporate funds applicable to such trades, and not by imperial taxes or local rates.

But with respect to those subjects which form the scientific basis of all arts and industries, and most of which are included in the syllabus of the Science and Art Department, the case is different. By granting Government aid to the teaching of these subjects all trades have an opportunity of sharing in the benefit in proportion to the number of workmen engaged. The Science and Art Department, by its system of payment by results, already does very much of what is wanted in this direction, but it is necessary to extend Government aid both above and below the class of students now attending Science and Art Classes. In the higher branches of scientific and technical teaching, such as should be undertaken by University Colleges, the system of payment by examination results is altogether unsatisfactory. Such teaching must be adapted to the special requirements of the class, and in any one session must cover a very limited range, if it is to be efficient and thorough. It is therefore impossible that it should be given in accordance with a syllabus issued by the central authority, and covering the whole range of a "subject." If there are to be examinations to test such work they must, like those following University Extension Lectures, be based entirely on the syllabus of the teacher, but it is better that aid to such classes should be given upon the number of students attending and the general character of the teaching and appliances provided. A definite sum annually contributed to each institution would be the most suitable form of grant, and its due admfnistration might be guaranteed by nominees of the Government being placed upon the governing body as in the case of the Welsh Colleges.

But while we have to provide for one stage of teaching above the Government science and art classes, there are at least two stages to be considered below them. In the first place there are the elementary schools which provide the only compulsory education which a child has to undergo. Here the foundations of a techinal training should be laid, and we would revise the code and train the teachers in such a way as to bring the teaching more into harmony with the life of the children. Kindergarten methods, for instance, might be adapted to the teaching of science in the higher classes, and instead of training children for the Stock Exchange when they are never likely to have £5 to invest, the time now devoted to stocks and shares and compound interest would be better expended upon workshop arithmatic, such as the calculation of the areas, volumes, weights, &c., of simple surfaces and solids. Drawing should have a very prominent place in the school curriculum and calisthenics should be encouraged in all classes, and not in the infants' school alone. The training of the eye and hand to work with tools other than drawing instruments, by the teaching of modelling or wood-carving or other art handiwork, which can scarcely be regarded as a trade, should be encouraged in the upper classes by a grant based on the inspector's report.

But when the child leaves school at 12 or 13 he is too young to profit by the Government Science Class, where he must be trained to earn a grant by examination, and yet it is of vital importance that his education should be continued. Here the recreative evening class supplies the need, but at present these classes are sadly crippled by the conditions under which a grant can be earned for them. Except in London it has been almost impossible to conduct recreative classes successfully, for, while the attendance is of necessity voluntary, the child on entering the school usually

finds that he is obliged to go back to one of the standards which he passed in the day school and again study the three R's in order to earn a grant. The teaching in the evening schools should be scientific, technical, and recreative, and the three R's should be taught incidentally only. For example, if a boy is learning experimental mechanics he will be expected to work out a few numerical examples, and write out the answers to certain questions, and the same will be the case if he is allowed to make experiments for himself. Here is an opportunity of teaching him arithmetic, writing, and spelling, and he will learn these subjects in connection with others in which he takes a real interest, and the direct application of which to his trade it is easy for him to see. Drawing, carving, and modelling should be taught in these schools, but no attempt should be made to teach a trade as such. To make it possible to conduct classes of this description successfully, the children must feel that they are not being manipulated in order to earn a grant by an examination, and Government aid should be given on the inspector's report of the attendance and general character of the teaching, or if there must be an examination it should be in the "specific subjects" taught, and not in the three R's, while the main portion of the grant should be given for attendance, but drawing and modelling should receive no inconsiderable portion. When the boy is 15 or 16 he may be willing to study science in a more serious manner, and in the Government science classes he will again be encouraged to work directly for examination results.

To summarise the whole, it seems that the requirements of the country in technical education would be met by—

1. Modifying the ordinary teaching in the primary schools so as to bring it more into harmony with workshop requirements.

2. Abolishing the three R's from the evening combination schools so as make the teaching given in them sufficiently attractive to draw voluntary profits and giving liberal grants for "recreative subjects."

3. Encouraging the formation of such institutions as the Polytechnic (which might in some cases be connected with university colleges) in which the science and art classes should receive aid from South Kensington, while the trade classes are supported by the trades of the district aided by such charities or corporate funds as may be available for the purpose.

4. Subsidising by an annual grant from the Treasury the scientific and higher technical teaching supplied by university colleges and similar institutions.

In the event of institutions being founded similar to the Polytechnic in districts where no local endowments are available, contributions to the building fund should be made by the Treasury to a much greater extent than the maximum of £1,000 now obtainable through the Science and Art Department.

The following notes of a system of State-aided technical education have been issued as a basis for discussion at a meeting of a provincial branch of the National Association for the Promotion of Technical Education. It is understood that in the third stage, as well as in the second stage, the whole of the teaching is given in the evening.

It appears necessary to consider four stages.

I.—Primary schools.

II.—Evening continuation schools.

III.—Science and art classes, and apprenticeship schools.

IV.—Higher technical and scientific education in university colleges.

I.—(1) In primary schools, the teaching should be brought more into harmony with the requirements of the workshop.

(a) By modification of the code.

(b) By training some of the elementary teachers in part, at least, in university colleges instead of training colleges, so as to bring them in contact, during their training, with practical men, who are always to be found attending such classes.

(2) Freehand drawing, practical geometry, and mechanical drawing should be taught in the primary school. In the upper classes, experimental mechanics and elementary physics, modelling, and wood carving should be added, the last two as recreative employments rather thantrades. *The teaching of specific trades should not be attempted under school Boards.*

II.—The evening continuation class being voluntary, but intended for boys between 12 and 15, must be made *as attractive as possible.* To this end,

(1) The three R's should not be taught as grant-earning subjects in the evening schools, but only incidentally in connection with specific subjects.

(2) The grant should be given for attendance, and for "specific" and recreative subjects, including drawing, modelling, and carving, examination results being made subsidiary to the inspector's report on the character of tha teaching.

(3) No specific trades should be taught.

With the evening continuation school, the functions of the School Board should terminate.

III.—Boys should pass on to the third stage soon after 15 years of age. In this stage, the Government science and art classes, and the apprenticeship classes, should be carried on side by side, if possible, in the same building.

(1) Government aid should be given to science and art classes, as at present.

(2) Where a science and art school, and an apprenticeship school, are accommodated in the same building, the grant to the *building fund* should not be restricted to £1,000.

(3) The teaching of each specific trade, in the apprenticeship school, should be under the supervision of a committee, *consisting mainly of members of that trade.*

(4) Eeach trade should determine in each district whether the requirements of the locality demand a workshop and the holding of practical classes in that trade in the apprenticeship school.

(5) No State-aid should be granted at present towards the current expenses of teaching specific trades, but the contributions of the members of each trade should, when possible, be supplemented by local charities, under the direction of the Charity Commissioners and Trade Guilds, and other corporate bodies, should be encouraged to assist.

IV.—In very large centres, a higher class of scientific and technical training should be provided for masters, managers, works' chemists, and other responsible persons, by means of university colleges.

(1) State aid should be granted to such colleges in the form of an annual subsidy, the amount of which should depend upon the extent to which the equipment of the college is adapted to meet the requirements of the district.

(2) The due administration of this subsidy should be secured by the appointment of two nominees of the Government upon the executive council of the college.

(3) Payment should be made to university colleges by the Education Department on account of any elementary teachers who are being trained at such colleges on the same scale as payments are now made to training colleges (suitable deductions being made for board and lodging).

THE LATIMER-CLARK VOLTAIC STANDARD OF ELECTRO-MOTIVE FORCE.

BY DESMOND G. FITZGERALD.

When a few facts and data relating to it are understood by the user, the Clark cell is probably the most accurate as well as the most convenient standard of e.m.f. that has yet been devised. Essentially, it is a voltaic couple in which the negative element is mercury in contact with mercurous sulphate ($Hg_2\ SO_4$) made into a paste with a saturated solution of zinc sulphate; and in which the positive element is zinc (necessarily amalgamated) immersed in a saturated solution of zinc sulphate, which again is saturated with the *nearly* insoluble mercurous sulphate. The zinc is usually also in contact with the solid mercurous salt. It was first described, I believe, in a paper by Mr. Latimer Clark, read before the Royal Society in 1872; its e.m.f. as measured in the B.A. units by means of the electro-dynamometer constructed for the British Association Committee, and also by means of a sine galvanometer, being given as 1·457 volt at 15·5° Cent (60° Fah).

But the question as to the value at the present time accepted for the e.m.f. of Clark's cell might be a somewhat puzzling one to many of the younger electricians for whom I am now writing. Of course the cell itself, made up in the same way at different periods, does not vary in E.M.F.; nor is the abstract volt ever different from 10^8 absolute electro-magnetic centimeter-gram-second units of electromotive force. Moreover the experimental determination by Mr. Clark of the E.M.F. of his cell, in making which it was assumed that the B A unit of resistance issued in 1865 was a correct expression of the ohm, has been very closely verified by Lord Rayleigh, who, *on the same assumption*, found the value to be 1·453 volt. Again, the value of the abstract ohm is, and will always be, 10^9 absolute *e – m* C G S units of resistance. But the reason why the E.M F. of Clark's cell, under certain given conditions is still in some measure a moot point is that electricians have been able, to obtain a closer approximation to accuracy in the material expression of the ohm in the form of a column of mercury or of a wire of a certain length and sectional area. It was in fact very soon found that the 1865 B A unit of resistance was defective, and lower in value than the true ohm. In the fifth report of the B A Committee on electrical standards, dated September, 1867, the value of the B A unit of resistance, based upon certain electro-thermal experiments of Joule in which 772 Manchester foot-pounds were taken as the dynamic equivalent of the British thermal unit, was given as ·9870 of the true ohm; whence the true ohm would be 1·0131 B A (1865) units. In the report of the same Committee, read at the Southport meeting of the Association in 1883, ·9867 ohm is taken as the value of the B A unit; this being almost identical with the value (·9868 ohm) arrived at by Lord Rayleigh and Mrs. Sidgwick in the same year. According to this determination, the true ohm would be 1·0135 B A (1865) units (or 1·0134 B A units if the higher value for the latter be taken).

In a paper which was published in *The Electrician* for May 10, 1884, Lord Rayleigh intimated that the experimental determinations conducted by himself and Mr. Sidgwick at the Cavendish laboratory were not yet quite terminated, and defines the ampere current as that which deposits per hour 4·025 grams of silver. He observes that "When we were provided with means for the absolute measurement of currents, the determination of electromotive force (E = CR) is a very simple matter if we assume a knowledge of absolute resistance. A galvanic cell is balanced against the known difference of potentials generated by a known current in traversing a known resistance. The difficulty relates entirely to the preparation and definition of the standard cells." In the same paper, Lord Rayleigh states that: "If we take the true value of the B A unit (of resistance) as ·9867 ohms, 1·453 volt (the value found by this experimentor for the E.M.F. of Clark's cell at 15 per cent. on the assumption that the B A unit of resistance is correct) will be replaced by 1·434 volt."

It will be seen that the ratio of the old and new values for the E.M.F. of Clark's cell is the same as that of the old and new values assumed for the B A unit of resistance, viz., 1 : ·9867. This observation may tend to remove a difficulty which has been encountered by some—perhaps by many—electrical students in accounting for the fact that the new value assumed for the E.M.F. of Clark's cell is *less* than the value originally assumed. This difficulty or puzzle—amusing perhaps to the proficient, but productive of annoying mystification to the solitary learner—arises from a process of reasoning which ignores the fact that the value of a unit and that of a quantity expressed in terms of the unit vary inversely. It is argued that as the unit of resistance was too small and required to be increased, and as the unit of current $\left(C = \frac{E}{R}\right)$ was taken as constant, therefore the voltage of Clark's cell, if accurately determined on the assumption that the unit of resistance was correct, would also be too small and would require to be incereasd. Here the facts are lost sight of, that a given absolute resistance would be expressed by a lower value in true ohms than in B A units of resistance, and that a given absolute E.M.F. would be expressed by a lower value in true volts than in B A units of E.M.F. Of course the correct reasoning would be that, as the unit of resistance was too small and required to be increased, therefore the unit of E.M.F. was too small and required to be increased, and therefore also the value of the E.M.F. of Clark's cell, in terms of the augmented unit, would be diminished. My sympathy with learners in all their difficulties must be my excuse for referring to this little matter at what some might consider undue length.

By resolution of the International Conference on electrical units, adopted at their meeting at Paris in April, 1884, the *legal ohm* was defined as the resistance of a column of mercury 1 square millimetre in section and 106 centimetres in length at the temseraturе of melting ice. The length of the same mercury column which gives the nearest approximation hitherto obtained to the true ohm is 106·24 centimetres. Thus the legal volt would be ·99774 of the true voit, and the true volt 1·00226 legal volt. And taking the E.M.F. of Clark's cell at 15° C as 1·435 true volts—the value given by Lord Rayleigh in his paper "On the Clark Cell as a Standard of Electromotive Force," read in January, 1886—its E.M.F. in legal volts would be 1·438.

In the recently-published paper by Sir W. Thomson "On the Application of the Deci-ampere or the Centi-ampere Balance to the determination of the Electromotive Forces of Voltaic Cells," the author states that "the results obtained for four Clark standard cells set up by Mr. J. T. Bottomley in March last were almost identical with one another, and gave 1·439 Rayleigh, or 1·442 legal volts at 11° C. The variation of the electromotive force of these cells with temperature has not yet been determined; but assuming the average value obtained for this variation by Lord Rayleigh, namely, a fall of ·077 per cent per degree centigrade rise of temperature, and correcting to 15° C, we obtain slightly under 1·436 Rayleigh volts at that temperature. This result is interesting, as showing a difference of tless than $\frac{1}{10}$th per cent. from that obtained by Lord Rayleigh for similar cells, which was 1·435 at 15° C."

It would be satisfactory to note as a fact so close an agreement as the above between two high authorities: still more satisfactory is it to be able to suggest that the agreement is really considerably closer. It is with some diffidence, however, that I venture to point out that Sir W. Thompson's corrected value should be very slightly *lower* instead of slightly *higher* than the value 1·435 volt obtained by Lord Rayleigh. But it seems to me clear that the agreement as above has been arrived at through an arithmetical oversight, which has, somewhat unaccountably, hitherto escaped detection. The result has obviously been obtained by multiplying the rate of variation per unit (·00077) into the difference of temperatures, and subtracting the product (·00808) from 1·439; the remainder being 1·43592, or "slightly under 1·438." But to obtain the fall in 1·439 volt due to a rise of temperature of 4°, it is not merely four times the rate per unit, but this value multiplied into 1·439, which has to be subtracted from 1·439. The remainder is then 1·4345 instead of 1·4359, a lower instead of a higher value than that (1·435) obtained by

Lord Rayleigh; and the percentage difference is only ·035 or less than $\frac{1}{25}$th, instead of "less than $\frac{1}{15}$th."

The result in any case justifies the conclusion that we may safely take 1·435 true volts, or 1·438 legal volts, as the normal E.M.F. of Clark's cell at 15° C., or 59° Fahr.

The formula given by Lord Rayleigh for the E.M.F. of a Clark's cell at a given temperature (t) is as follows:—

$$E = 1{\cdot}435\left\{1 - {\cdot}00077(t - 15)\right\}.$$

For the benefit of the young learner, I will point out that this may take the form:

$$E = 1{\cdot}435 - 1{\cdot}435 \times {\cdot}00077 \times (t - 15),$$

and that when ($t - 15$ gives *minus* value its product with the second *minus* value is *plus*.

By the application of this formula, it will be found that the E.M.F. of Clark's cell at 11° C. should be 1·4394 volt, thus confirming in a striking manner the result given in the above extract from Sir W. Thomson's pape as having been obtained by direct experiment.

According to Profs. Ayrton and Perry (see *The Electrician* for January 8, 1886, p. 168), the temperature variation amounts to about 1 per cent. diminution per 12° C. elevation of temperature, corresponding to a coefficient of ·00083 in the above formula.

In regard to the causes which affect the normal E.M.F. of Clark's cell, the most frequent source of error is the occurrence of supersaturations in the zinc sulphate solution. Great attention has recently been given to this point by Messrs. Elliott Bros., who have found it necessary to adopt special precautions in order to obviate the diminution of E.M.F. arising from this cause. In the valuable paper by Lord Rayleigh already referred to, the under-saturation of the solution, resulting in an E.M.F. higher than the normal, is referred to, as well as the above, as a source of error. But for every cell in which I have observed the E.M.F. to be above the normal by reason of failure to saturate the fluid with zinc sulphate, I have found at least twenty in which the E.M.F. was too low by reason of supersaturation. Many cells were formerly made up with a paste produced by triturating crystals of sulphate of zinc, with moist mercurous sulphate in a mortar. Comparing a cell made up in this way with another in which the zinc solution was just saturated, I have found the former to be 1·7 per cent below the normal, even before supersaturation proper—brought about by rise of temperature and gradual cooling—had occurred. When the solution is supersaturated the fall of E.M.F. below the normal may exceed 2 per cent.

When the cell is made up strictly in accordance with the following directions, extracted from Mr. Latimer Clark's original paper read before the Royal Society in 1872, supersaturation—the condition in which a fluid will deposit crystals if a crystal be dropped into it or if it be violently shaken—is very likely to occur through unduly prolonged heating to expell air. The opposite error of undersaturation is, in the given case, of course out of the question.

"The best method of forming this element is to dissolve pure zinc sulphate to saturation in boiling distilled water. When cool, the solution is pound off from the crystals and mixed to a thick paste with pure mercurous sulphate, which is again boiled to drive off any air; this paste is then poured on to the surface of the mercury previously heated in a suitable glass cell; a piece of pure zinc is then suspended in the paste, and the vessel may be advantageously sealed up with melted paraffin wax. Contact with the mercury may be made by means of a platinum wire passing down a glass tube cemented to the inside of the cell and dipping below the surface of the mercury, or more conveniently by a small externol glass tube blown on to the cell, and opening into it close to the bottom."

It may here be pointed out that in the glass cells as usually made the external tube is not made to open into the cell sufficientlly close to the bottom. An unnecessarily large quantity of mercury has therefore to be used, and the probable ill effect of any shaking or concussion of the shell is facilitated. Although paraffin fairly answers the purpose in view, it must be admitted that it cannot be depended upon for the hermetic closure of the cell. It frequently allows of the escape of fluid by capillarity; and, after a certain time, the E.M.F. falls about 2 per cent. below the normal by reason of the supersaturation of the solution and the formation of crystals of zinc sulphate. Some steps have already been taken to remedy these shortcomings, the indication of which will doubtless have the effect of hastening improvement.

The importance of using pure materials in the construction of the cell need scarcely, one would think, be insisted upon at the present time. The mercury salt in perhaps most of the cells in use several years ago was of a yellow colour—this indicating that the mercurous or sub-salt was contaminated with the mercuric or per-salt ($HgSO_4$); the latter becoming decomposed in presence of water into an acid salt and a basic salt of a yellow colour. That of the pure mercurous salt is a greyish white. The excess of acid in this salt, as usually prepared, may be removed by the addition of a little oxide or carbonate of zinc; but perhaps the best, though the most wasteful, method of purification, is copious washing with distilled water.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

In the Inaugural Address of the President, Mr. John Purser Griffith, reference is frequently made to the part which electricity plays in engineering matters. The following paragraph show a number of the uses in which engineers recognize the utility of electricity. Mr. Griffith said:

"I have referred to the safety with which we can travel on our railways. For this we are specially indebted to the electric telegraph, by which our block systems are controlled. Electrical engineering has now becomea recognised branch of our profession, and we are constantly calling electricity to our aid. Its application to telegraphy only dates back to 1837. The first line was laid under ground between Euston and Camden Town. The difficulty of maintaining the insulation led to the use of the unsightly poles and overhead wire with which we are so familiar. On the railways of England, Scotlond, and Ireland, we have now over 69,000 miles of wire in use. But, perhaps, the most remarkable progress has been made in submarine telegraphy. Many of us can recall the attempt made to lay the first Atlantic cable. Aow the land was filled with anxiety respecting the result, and what disappointment followed its failure! Now nine cables cross the Atlantic, ond England is bound bʎ other lines to China, India, Australia, New Zealand, and the Cape. More than 80,000 miles of submarine cables are now at work and by their success the ideas of time and pistance upon which we were brought up have received rude shocks. Perhaps nothing has been more remarkable than the skill exhibited in increasing the capacity of these wires for the transmission of messages. In place of manual labour, by which 30 words per minute can be sent by a skilful operator, we now have a mechanism which will transmit 250 words per minute; and by the introduction of duplex and quadruplex telegraphy, two or four messages can be transmitted on one wire at the same time.

"Telegraphy is but one of the directions in which electricity is useful to the engineer. The telephone, as a time-saving instrument, is familiar to us all, and I need scarcely refer to it beyond remarking that but for the convenience of rapid communication it would be expelled from many an office as an unqualified nuisance and rude companion. There is one application of the telephone which has been of special value—that is, as a means of communication between divers and their attendants above water. Anyone who has experienced the sensation of finding his life-line and air-tube entangled while in deep water, will appreciate the advantages of such a means of communication. It has added much to the safety of diving operations, and facilitates the men's work. Electricity has also been applied with great success to blasting operations, superseding in large works the dangerous and uncertain fuse. The most successfu instances of its use for this purpose have been in the removal of the reef at Hallett Point in the East River, New York, known as Hell Gate, and the Flood Rock. In the former explosion 4,427 separate charges were simultaneously fired, and a reef covering an area of 3 acres and containing 63,000 cubic yards of rock, was demolished. The Flood Rock, or Middle Reef, covered an area of 9 acres, and 270,717 cubic yards of rock were shattered by the explosion, which was successfully carried out on the 10th of October, 1885.

Considerable progress had been made in the utilisation of electricity for the transmission of power from a distance. In Ireland we have two examples of electric tramways at work—one from Portrush to the Giant's Causeway, the second from Newry to Bessbrook in County Down.

"In electric lighting the progress, though not as rapid as was expected some yeaɹs since, has been very marked. The use of search-lights on steamships has enabled vessels so equipped to navigvte the Suez Canal at night, and the dassage through the Canal can now be accomplished in 16 hours instead of 36 hours. This, obviously, has added to the capacity of the Canal for the passage of shipping, and will probably postpone the necessity of a second canal for many years.

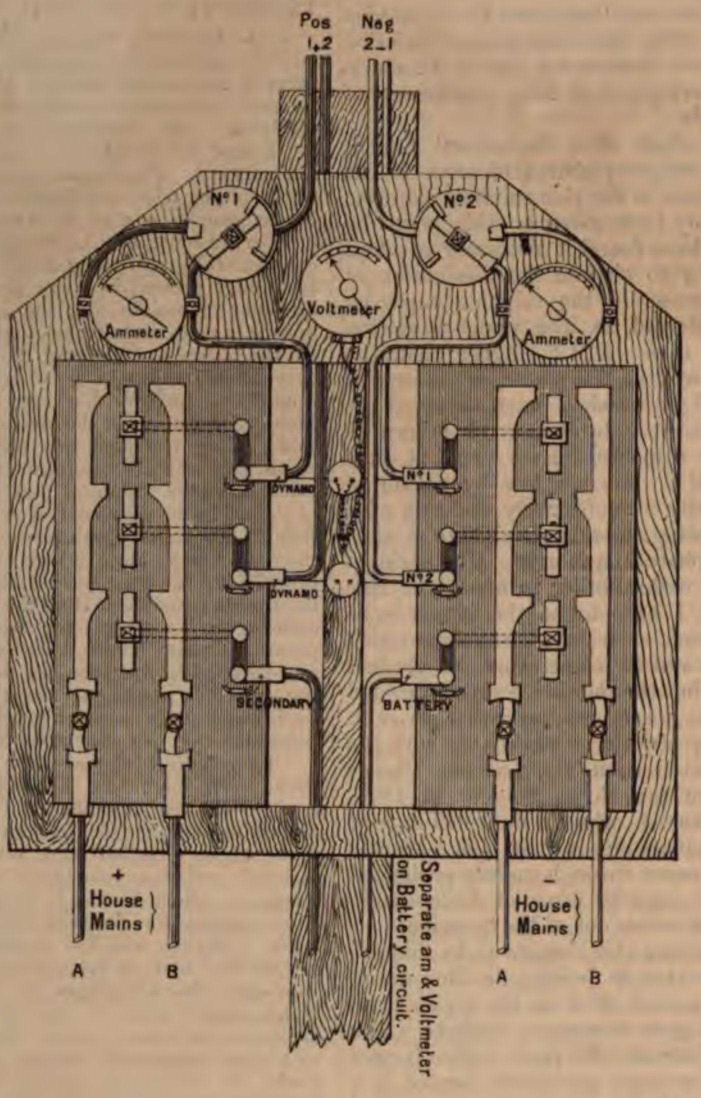
ENGINE ROOM SWITCH-BOARD.

DESIGNED BY W. H. MASSEY.

Of all the accessories of electric lighting a simple and effective switch-board is one of the most important. We herewith illustrate a simple form of engine room switch-board which has been designed by Mr. W. H. Massey. The switch-board is in use in several large installations, and has been designed with the object of enabling engine drivers and others in charge of electric lighting apparatus to see at a glance how the various circuits under their charge are coupled up. We have seen switch-boards that were wonders of ingenious contrivances, and turned away with the sad reflection that life was really too short to venture upon the study of their hidden mysteries. Mr. Massey's design certainly cannot be said to err on the side of complexity, but may be acknowledged to be as he terms it, a simple switch-board. All the connections are easily got at, and it is not necessary to remove a number of connections amounting in some instances to a considerable percentage of the whole board, in order to take out a pair of leads.

The board now illustrated is suitable for two dynamos giving 250 amperes each, and a set of secondary batteries of large dimensions. The connections are shown by the diagram, so that it is not necessary to enter into this detail. For the ordinary day-work of an installation one dynamo may be coupled to one set of house mains, if required, while the other is being used to charge the secondary batteries.

Separate volt and ammeters are placed in the battery circuit for use when the battery is discharging. These, as will be seen, are not shown in the illustration, but the connection is easily understood. Generally speaking, for night working, one pair of house mains is amply sufficient; but, on special occasions, such as when parties or balls are being given at large mansions, the service would be by the two-house mains, both engines, one on each circuit, being employed. On such an occasion the secondary battery may be used as a stand-by, or for giving the current to those lamps which are required to be burnt all night. Of course this is but a brief description of an apparatus for which there is many an arrangement. We have spoken of dynamos always in use with a secondary battery as a stand-by; of course this is not the case, as on Sundays, and frequently in summer, the engines might not be required to run at all during the day.



PARIS AND SCOTT'S NEW C-TYPE DYNAMO.

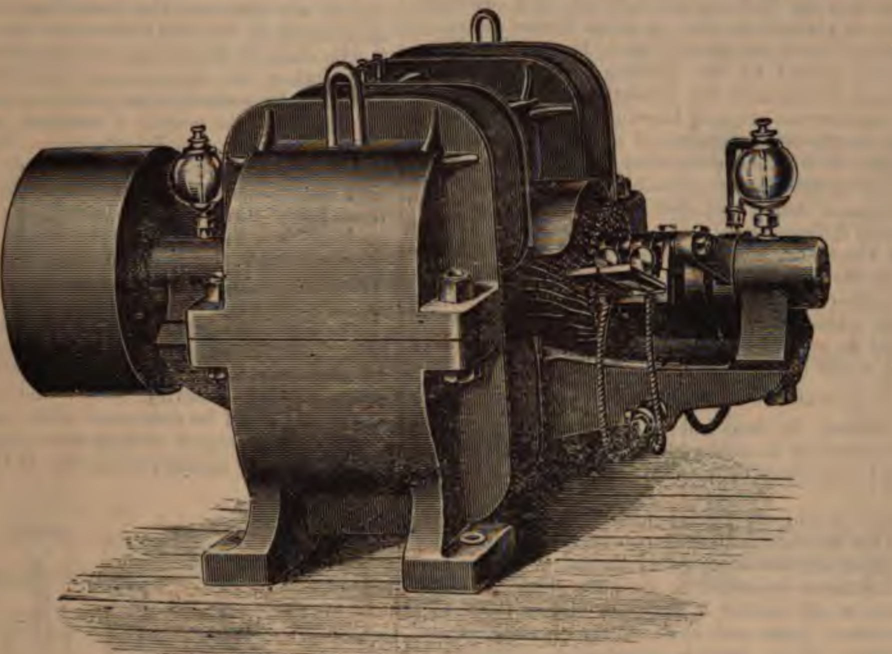
In this machine, illustrated below, the conductor on the armature is wound in deep and narrow slots cut in the iron plate forming the armature core. The result of making the slots very narrow is that the noise and heating of the pole-pieces usually produced in machines with toothed armatures are entirely absent, as the armature presents what is practically a continuous face to the pole-pieces; and by making the slots very deep there is plenty of room for a large quantity of conductor to be wound on, and also for the especially good and thick insulation which is used, the makers considering that durability and freedom from risk of break-down are of first importance. Other considerations, however, have not been sacrificed, the magnetic resistance is low, and a field in the armature core of

23·6 Kapp units per square-inch sectional area is produced with a very small expenditure of power in the field magnets, so that the electrical efficiency is high, especially when the comparatively low speed 850 revolutions is taken into consideration,

The resistance of armature is . . .	·029	ohms
„ „ magnets	35·	„
Loss in armature with 120 am. . . .	317.5	watts
„ magnets „ 100 volts . .	286·	„
Total electrical loss . . .	703·6	

Showing an electrical efficiency of over 94 per cent.

The field magnets are of cast iron, by the use of which the cost of the machine is very much reduced. And although this cast iron is of great sectional area, being three times that of the iron in the armature core, yet the total weight of the machine illustrated, having an out-put of 12,000 watts at 850 revolutions, is only 1,268 lbs. Of this the armature complete weighs 147 lbs. Where lightness is important—as in some motors and in ship lighters—by using wrought iron for the field magnets the weight of machines with this type of armature is greatly reduced. The mechanical construction of these armatures makes them suitable for motors for tramcar and electric railway work; the plates forming armature core being made with a hexagon hole and threaded on to a hexagon shaft; so that each one is driven direct, and as the conductor is wound in slots in the plates the torque which the whole will stand is manifestly very great.



Paris and Scott's Dynamo.

SCIENCE EXAMINATION IN TRAINING COLLEGES.

MAGNETISM AND ELECTRICITY.

The following examination paper was set for the purpose of testing the knowledge of our future schoolmasters in magnetism and electricity. We could almost imagine that the world had stood still during the past fifty years so far as this subject is concerned if these examination questions were any guidance to the present state of electrical knowledge. Surely it is time that those who control the examinations should insist upon some questions being given to test the student's familiarity with recent developments of the subject. How many electric light engineers could answer the questions, or would acknowledge that any one pf them had a bearing upon the practical part of their work?

Division I.

1. Two gold leaf electroscopes, A and B, are placed at a considerable distance apart, and an unelectrified slab of shellac is laid upon the cap of A. Two positively electrified balls are then brought near the caps of A and B respectively, and the electroscopes are for a moment connected with earth. Explain the behaviour of the leaves if without any other change in the apparatust he slab of the shellac is transferred from A to B. 15

2. A kettle which can be held by an insulating handle is positively electrified, and water is poured from it into an insulated metal teapot. How are the electrical states of the kettle, water, teapot altered during the process? 20

3. How would you construct an electrophorus from which charges of negative electricity could be obtained? 10

4. Two small equal metal balls charged with equal quantities of positive electricity are placed at a fixed distance from each other. They are then touched in turn with an unelectrified insulated metal ball of the same size, which is not discharged between the two contacts. In what proportion will the force between two balls be diminished? 15

Division II.

5. If you were given a galvanic cell, wire, and a compass, how would you determine which was the positive pole of the cell? 10

6. Three similar wires are joined together so as to form an equilateral triangle A B C. Two corners of the triangle, A and B, are joined to the poles of a battery. Will all three sides be equally heated by the current? Give reasons for your answer. 15

7. An observer looking down upon a copper ring drops through it a bar magnet north-seeking end first. In what directions would the current produced in the ring appear to him to circulate (1) before, (2) during, (3) after, the passage of the magnet through the ring? 20

8. The resistance of a tangent galvanometer is 20 ohms, and a current passess through it which deflects the needle 60°. It is shunted by a certain resistance, and the resistance of the rest of the circuit is altered so that the total current is the same as before. If the needle is now deflected through 30°, what is the resistance of the shunt?

[N.B.—Tan. $60^\circ = \sqrt{3}$, tan. $30^\circ = \frac{1}{\sqrt{3}}$ 15

Division III.

9. A bar magnet is placed to the south of a compass, and in the magnetic meridian which passes through the centre of the compass needle. If the south-seeking end of the bar-magnet points north, explain the behaviour of the compass needle as the magnet is brought nearer to it. 10

10. An iron hoop is held in the plane of the magnetic meridian. Describe its magnetic state. 15

11. The upper end of a dipping needle is weighted with wax until it will remain in any position in which it may be placed when free to move in a plane perpendicular to the magnetic meridian. Describe the effect (if any) of turning the instrument round so that the needle moves in the magnetic meridian. Give reasons for your answer. 20

12. A bar magnet and an iron rod are placed in the same straight line, and iron filings are strewed on a sheet of paper which is laid over them. Describe, with a sketch, the form of the curves assumed by the filings when the paper is tapped. 15

PORTABLE VOLTMETERS FOR MEASURING ALTERNATING POTENTIAL DIFFERENCES.

BY PROFESSORS W. E. AYRTON and JOHN PERRY.

It is now well understood that a high-resistance electro-dynamometer cannot generally be used for measuring alternating potential differences, in consequence of the self-induction of the dynamometer causing the effective resistance—and therefore the sensibility—of the dynamometer to vary with the speed of alternation. Further, even for the measurement of direct potential differences an ordinary high-resistance voltmeter, employing the magnetic property of the current, is not entirely satisfactory if the forces employed be large (as they generally have to be in dead-beat portable instruments), since, in that case, the current, if kept continuously on, slowly heats the voltmeter, and by increasing its resistance causes its sensibility to diminish. It has, therefore, for some time seemed clear that the heating effect of a current should be used for voltmeters.

Captain Cardew was the first person to utilise this principle in the construction of voltmeters, and, as far as we are aware, is the only person who, up to the present time, has employed the extension of a wire, caused by the heating produced by the passage of a current, to measure the potential difference at its terminals. His instruments are well known, and have afforded most valuable aid in the measurement of alternating potential differences; and we, in common with other electrical engineers, owe him a debt of gratitude for providing us with the only commerccial instrument that has existed for the measurement of alternating potential differences.

In "Practical Electricity" an attempt has been made to impartially sum up the advantages and disadvantages of all the more important ammeters and voltmeters, and we cannot do better than repeat what was there said about the Cardew voltmeter, especially as we understand that Captain Cardew considers the criticism to be a fair one.

"CARDEW VOLTMETER.

"*Advantages.*—First, it has but a small heating error; second, the self-induction is negligible. It is also dead-beat, direct-reading, not disturbed by magnets, and fairly portable, althoug large.

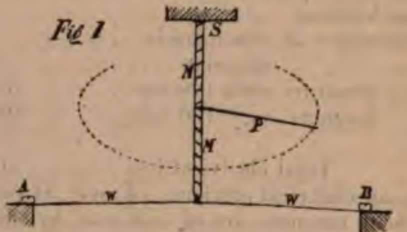
"*Disadvantages.*—It absorbs a good deal of energy; second, it cannot be used for measuring a small potential difference, for we cannot make it of thicker wire, as we should do in the case of an ordinary voltmeter intended to measure small potential differences, as this would render it sluggish, since a thick wire traversed by a current heats and cools slowly on starting and stopping the current; third, there is considerable vagueness in the readings near the zero point, and sometimes inaccuracy in the upper parts of the scale."

Towards the end of 1885 we were engaged on certain experiments on the governing of transformers in series to give a constant potential difference at each house, and, as our experiments were to be conducted with small transformers, we required a voltmeter which would measure an alternating potential difference of three or four volts with accuracy. Such an instrument not being in the market, we were compelled to devise one; and we were led to consider whether the Cardew principle might not be employed in an instrument which should give quite definite readings even near the zero, and produce a large deflection when an alternating potential difference of a few volts was maintained between its terminals.

Part of the vagueness in the readings of the Cardew instrument we saw was due to the employment of toothed wheels; and, as explained in a paper* read by us before the Royal Society in 1884, toothed wheels have not recommended themselves to us as a means of magnification in ammeters and voltmeters, in consequence of the friction they are liable to introduce. In fact, after giving toothed gearing an extensive trial in our instruments, originally described to this Society† in 1882, we decided to abandon its use in 1884.

If a voltmeter depending for its action on the expansion of a wire by heating is to be sharp in its action, the wire must be fine; and if it is to measure a small potential difference the wire must be short; hence we were led to consider whether it was not possible to construct a voltmeter of quite a short length of fine wire, and observe its extension with some frictionless magnifying arrangement. This led us to consider the platinum wire telephone described by Mr. Preece in his paper‡ read before the Royal Society in 1880, which, although composed of but a short length of wire, evidenced by the motion of the diaphragm, to the centre of which one end of the wire was attached, every change in the current passing through it. After thinking out various means of attaining this result, we were led to see that one of our magnifying springs, described to this Society in 1882, furnished the means of obtaining a sufficiently sensitive frictionless magnifying arrangement. For experiment shows that if a short piece of fine wire *WW* (Fig. 1) only seven inches long be

Fig 1



stretched between two supports *A* and *B* to which it is *rigidly* attached, and if it be pulled slightly out of the straight line by one of our right and left-handed magnifying springs *M*, *rigidly* attached at its one end to the wire and at the other to a support *S*, the axes of the spring and the wire being at right angles to one another, the arrangement is so delicate that the expansion produced by even the approach of a warm hand is evidenced by the rotation of a pointer *P* attached to the centre of the right and left-handed magnifying spring. The absence of all gearing and the rigid fastening of both ends of the spring, combined with the fineness of the wire, make the arrangement remarkably remarkably dead-beat in its action; and when the wire is enclosed in a short metal tube we have a voltmeter which will measure even the fraction of a volt, whether the potential difference be direct or alternating, since the readings even near the zero are quite definite.

The right and left handed spring was employed to avoid any twist being given to the wire; but one of our assistants—Mr. Bourne—who has worked at this instrument with his customary ingenuity and dexterity, soon found out that half the length of the spring could be dispensed with, and an equally efficient but much more compact arrangement could be effected by using a single ordinary magnifying spring *M* (Fig. 2) and introducing a

Fig 2

small piece of fine wire *C D* between the one end of the spring and the stretched wire *W W*, or between the other end of the spring and the support *S*.

To get extreme quickness of action on changing the potential difference, it is desirable to employ a thin wire; and as the strength of such a wire is small, the next step was to combine a number of wires mechanically in parallel, and electrically in series or parallel, the wires being attached at their middles to a stirrup which is carried by the magnifying spring; and voltmeters containing as many as twelve short wires, each about seven inches long, were made in the early part of the summer of 1886.

These instruments showed, however, the sluggishness which is familiar to the users of the Cardew voltmeter, and we had to set ourselves to investigate it. Stationary metallic screens were inserted between the wires to assist the cooling, and various other means tried, without success, when we set Mr. Bourne to investigate the general question of sluggishness. A variety of experiments were made by him on the rate of variation of the permanent state of a wire with the variation of potential difference at its terminals, as affected by varying the proximity of the wires, their length, &c. This occupied him several weeks, and the experiments he made were too numerous to be recorded here. With our many-wire voltmeter the sluggishness was certainly not due to mechanical friction, as our magnifying spring is practically frictionless; and we gradually saw that the peculiar creeping back in the deflection of a Cardew voltmeter, when a perfectly constant potential difference was first set up between the terminals, was due to the fact that the draught of air created in the tube by the heated wires takes an appreciable time to be produced, so that the wires are hotter directly the potential difference is applied than they become when the draught begins to flow. A number of more or less successful devices were tried for overcoming this defect—for instance, even the employment of a draught independently maintained—when we found in the summer of last year that the simple device of placing the tube horizontal instead of vertical, and using very fine wire—not much exceeding one-thousandth of an inch in thickness—overcame all the difficulty. The importance of placing the tube horizontal was also subse-

* "A New Form of Spring for Electric and other Measuring Instruments."

† "Measuring Instruments used in Electric Lighting and Transmission of Power."

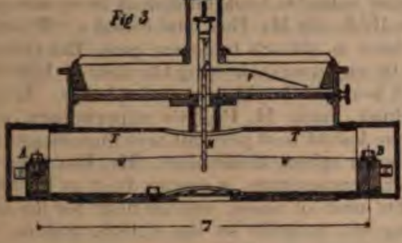
‡ "Thermal Effects of Electric Currents."

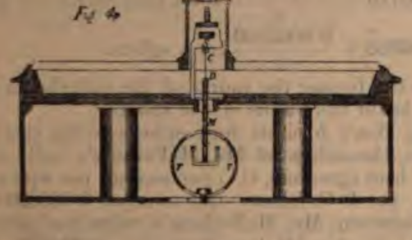
quently seen by Mr. G. S. Ram this year, and consequently the scales of the Cardew voltmeters are now marked so that the zero is at the top when the tube is placed horizontal.

This home-made instrument with two wires lying on the table was then completed in August of last year, and was found to be remarkably sharp and decisive in its action—to give a deflection of 300° with 14·22 volts maintained at its terminals. Even a fraction of a volt can be measured with it, as the readings are quite definite even near the zero.

The finest wire employed by Captain Cardew in his commercial instrument has a diameter of 0·0025 of an inch; but, in consequence of our magnifying gearing being frictionless and comparatively massless, we are able to use much finer wire—not more than 0·0014 of an inch in diameter—without any fear of injury, even if the instrument receive a sharp knock. This greater fineness of the wire gives us three times as much resistance per foot, and therefore enables the instrument to be very much smaller; also, as the ratio of service to sectional area is far greater, the heating and cooling is far more rapid—that is, the instrument is much more dead-beat.

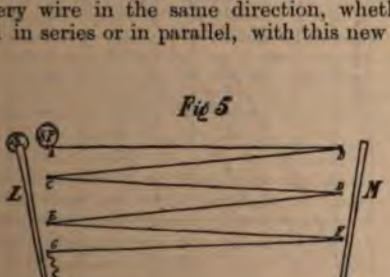
Figs. 3 and 4 show two sections at right angles to one another





through the centre of this other two-wire voltmeter which is lying on the table. It has been constructed on the lines of the original one, but in a more workmanlike manner. It is direct-reading, and measures from 0 to 10 volts, the deflection for that potential difference being some 250°. The same letters are employed to designate the various parts of the instrument as were used in Figs. 1 and 2, with the addition of T, the metal tube surrounding the wires; and the stirrup connecting the end of the magnifying spring with the wires is also shown.

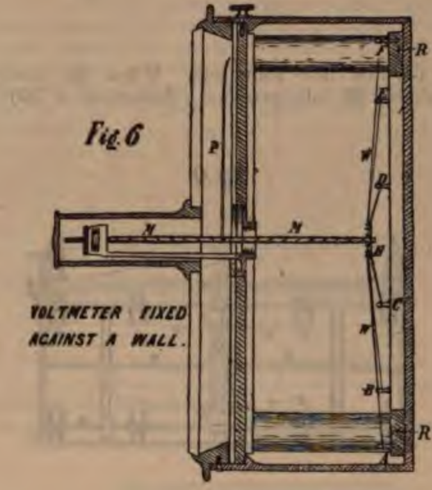
The employment of several short parallel wires soon suggested the addition of the commutator described in our paper read before this Society in 1881, for varying the sensibility of a voltmeter. But whereas with our commutator ammeters and voltmeters in which the magnetic action of a current in deflecting a magnetised needle was employed the current had to flow through every wire in the same direction, whether the wires were joined in series or in parallel, with this new form of volt-



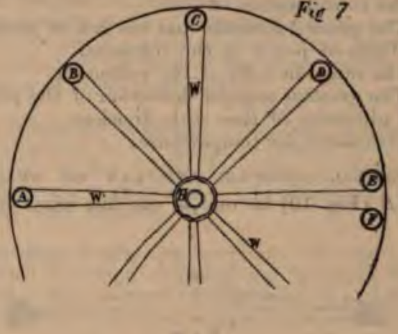
meter in which the heating property is employed it is unimportant which way the current passes through a wire. Hence the pins in the barrel of our old commutator which gave trouble may be entirely dispensed with, and the commutator assumes a very simple form. In fact, if AB, BC, CD, DE, FG, (Fig. 5), represent wires joined in series in the new form of voltmeter, the series connections need not be disturbed when a parallel arrangement is required, since all that need be done to join them in parallel is to connect the points A, C, E, G, by means of the bar L, and B, D, F, by means of the bar M. S and SP are the terminals for series, and P and SP for parallel; so that if the commutator be accidentally turned from series to parallel the circuit is broken and the wires are not fused. This instrument lying on the table is a four-wire voltmeter, and the sensibility is such that 15·2 volts gives a deflection of 38° when the commutator is turned to series, and 295° when it is turned to parallel.

It is important to notice that the employment of this commutating device to vary the sensibility enables all the wire in the instrument to be always operating in deflecting the pointer; whereas if the ordinary device of adding an outside resistance coil be employed to enable the voltmeter to measure a larger number of volts, the energy spent in heating this outside resistance coil is entirely wasted as far as deflecting the pointer is concerned. In fact, the greater the outside resistance, the more inefficient becomes the voltmeter.

For the object of still more completely carrying out the principle of employing a number of short wires, we have also made voltmeters in the following way:—The wires are arranged like the spokes of a small bicycle wheel $W W$ (Fig. 6); that is, we



have a circular rim of a wheel R, which may be of the same metal of which the wires are made, to eliminate errors due to change of temperature, fitted with non-conducting studs A, B, C, D, &c., to which the wires are attached. There is also a small non-conducting central piece H, corresponding with the hub of a wheel, to which the wires are also attached; and as the wires come from rim to middle backwards and forwards several times, the arrangement appears like a bicycle wheel with many spokes, as seen in Fig. 7. One end of a right and left-handed

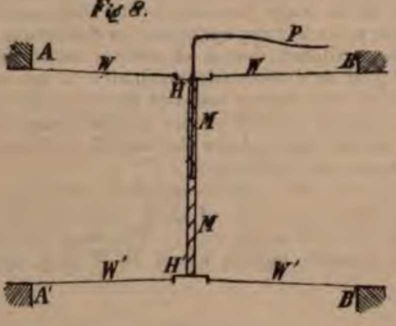


magnifying spring M (Fig. 6) under tension is rigidly attached to the hub H, and its other end to the support S. Hence, as the wires expand on heating, the spring draws the hub H more out of the plane of the rim R, and the rotation of the pointer P measures the current. This instrument on the table is made exactly in this way. Using two of its three terminals, the range is from 0 to 50 volts; or using one of the previous ones and the third, it is from 0 to 100 volts. In both cases, however, the whole of the wire is operative in deflecting the pointer.

Fig. 8 shows a voltmeter made with two bi;ycle wheels. The letters attached to one of them refer to the same parts as the letters used in Fig. 6, while similar accented letters are used for the similar parts of the second bicycle wheel. As before, one end of the right and left-handed magnifying spirng is attached to the hub of one of the wheels; but instead of the other end being rigidly attached to the case of the instrument it is attached to the hub of the other wheel. Hence the rotation of the pointer is produced by the expansion of all the wires on both wheels. Fig. 9 shows the actual arrangement of the double bicycle-wheel

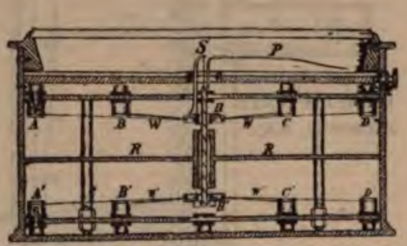
voltmeter on the table, where an ordinary (not a right and left-handed) magnifying spring M is employed, with a flexible connection of fine wire carried by the support S, which itself is carried by the hub H of one of the wheels. The wires are

Fig 8.



electrically divided into four sets. When the commutator is turned to series, 80 volts produce a deflection of 300°; whereas

Fig 9.



20 volts produce a deflection of 300° when the commutator is turned to parallel.

In Fig. 6 of the single bicycle-wheel voltmeter the instrument is shown with the dial vertical. But any one of the forms described in this paper may also be used with the dial either horizontal or vertical.

The action of these instruments is quite easy to understand; but the mathematical calculation of the way in which the deflection of the pointer for a given potential difference is varied by varying the dimensions of the magnifying spring, the initial sag given to the wire, and the dimensions of the wire, is not quite so easy to work out. We have, however, succeeded in reducing the solution to a comparatively simple form, and the following comprises the consideration of—

A. The general formulæ and the law of graduation.
B. Waste of power in the voltmeter.
C. The range in volts of the voltmeter.
D. The greatest angular deflection of the pointer.
E. Uniformity of thee scale divisions.
F. Correction for temperature.

A.—GENERAL FORMULÆ AND LAW OF GRADUATION.

Let $A\,O\,B$ (Fig. 10) be one of our fine wires or two opposite

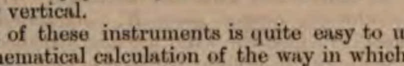


Fig 10

spokes of our bicycle-wheel form of voltmeter, the size of the hub being neglected. Let

$$X\,O = O\,B = \tfrac{1}{2}\,l,$$
$$O\,Q = y.$$

Let the diameter of the wire be d, and the specific resistance of its material be ρ when its temperature is θ degrees above the temperature of the surrounding metal case: then, if the case does not alter greatly in temperature,

$$\rho = \rho_\circ\,(1 + k\,\theta) \qquad \dots \quad \dots \quad \dots \quad (1)$$

where k is the coefficient of increase of resistance per degree centigrade, and $\rho_\circ$ is the specific resistance of the material when θ is nought.

When $\theta = 0$,
let $l = l_\circ$,
and $y = y_\circ$:
then $l = l_\circ\,(1 + a\,\theta)$,

where a is the coefficient of increase of length per degree centigrade.

$$y^2 + A\,Q^2 = \tfrac{1}{4}\,l^2,$$
$$y_\circ^2 + A\,Q = \tfrac{1}{4}\,l_\circ^2;$$
$$\therefore y - y_\circ = \tfrac{1}{2}\,l_\circ^2 a\,\theta, \text{ approximately} \quad \dots \quad (2)$$

since a is small.

In that very useful treatise of Dr. Everett's, "Units and Physical Constants, there are given the results of Mr. McFarlane's and of Professors Tait's experiments on the rate of loss of heat in air at ordinary pressure from copper for various differences of temperature between the copper and the surrounding space, but no indication is given as to the form of the radiating body, nor of its size; and hence people have used Mr. McFarlane's results as if they applied to bodies of any shape and size, and so have been led in some cases to erroneous conclusions. As a matter of fact, Mr. McFarlane's values for the rate of loss of heat by radiation and convection given in Dr. Everett's "Units and Physical Constants" *apply only to a copper ball of 2 centimètres radius*, since this, we find, was the cooling body employed by Mr. McFarlane in the experiments in question, as mentioned in Mr. McFarlane's paper communicated by Sir W. Thomson to the Royal Society in 1870.

But in a very valuable book published two years previously to that—viz., in 1868—by Mr. Box, and called a "Practical Treatise on Heat," there is given a table on page 151 (which has been much used by engineers) showing the loss of heat from contact with air with horizontal cylinders and spheres. It was deduced, we rather think, from M. Peclet's experiments, and it shows clearly that the loss of heat per unit area increases as the diameter of the cylinder or sphere diminishes. Mr. Box used the Fahrenheit scale for temperature, a square foot as his unit of area, a pound for his unit of mass, and an hour for his unit of time; but, reducing his formulæ to the C.G.S. system, we find that the loss of heat (gramme, C.°) per second, per square centimètre of surface, per 1° C. excess, is

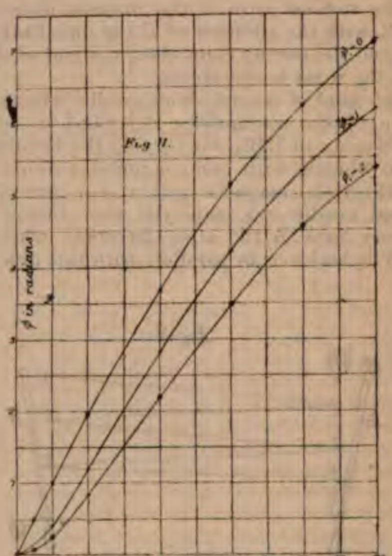
$$0{\cdot}00005710 + \frac{0{\cdot}0001057}{a} \text{ for a long } \textit{horizontal} \text{ cylinder,}$$

$$\text{and } 0{\cdot}00004928 + \frac{0{\cdot}0003509}{a} \text{ for a sphere,}$$

a being in the former the radius of the cylinder in centimètres, and in the latter the radius of the sphere.

Applying Box's formula for a sphere to the case where a *is* 2 centimètres, the radius of Mr. McFarlane's ball, we obtain for the loss of heat (gramme, C.°) per second, per square centimètre of surface, per 1° C. excess, the number 0·0002297—a number which is between Mr. McFarlane's value for polished copper (0·000178) and for blackened copper (0·000252). There is, therefore, every reason for believing that Box's formula is at any rate approximately correct.

Let us take as a first approximation that the rate of loss of heat is directly proportional to the difference of temperature.



This we know is not strictly true, and the error arising from the assumption will be further considered under section B—"Waste of Power in the Voltmeter." Then, if $\epsilon\,\theta$ be the heat-power *in watts* given out per square centimètre of surface of the wire when the excess of temperature is θ° C.,

$$\epsilon = \frac{0{\cdot}00005710 + \dfrac{0{\cdot}0001057}{a}}{0{\cdot}239}.$$

Now the resistance of the wire is $\dfrac{4\,l_0\,\rho}{\pi\,d^2}$; so that if V volts be

the potential difference at its terminals, $\frac{V^2 \pi d^2}{4 l_0 \rho}$ watts are developed in the wire, and $l \ \pi d \epsilon \theta =$ heat-power emitted in watts; so that

$$l \ \pi d \epsilon \theta = \frac{V^2 \pi d^2}{4 l_0 \rho} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

or

$$\theta = \frac{V^2 d}{4 l_0^2 \epsilon \rho} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

If the thickness of the wire be very small, and if Box's formula continue to hold for very thin cylinders,

$$\epsilon = \frac{0 \cdot 0001057}{0 \cdot 239 \, a}, \text{ approximately};$$

$$= \frac{0 \cdot 0008848}{d}, \quad \text{,,}$$

hence

$$\theta = \frac{V^2 d^2}{0 \cdot 003539 \, l_0^2 \rho}, \quad \text{,,}$$

so that to raise a fine wire of a given length, made of a given material, to a given temperature above that of the case of the instrument requires that the potential difference maintained at the ends of the wire shall be inversely proportional to the diameter of the wire, approximately.

If C be the current in amperes flowing through the wire,

$$C = \pi d^{\frac{3}{2}} \sqrt{\frac{\epsilon \theta}{4 \rho}}$$

Substituting the value just obtained for ϵ for very fine wires, we have

$$C = 0 \cdot 01487 \ \pi \ \mathrm{d} \sqrt{\frac{\theta}{\rho}}, \text{ approximately};$$

or the current required to maintain a fine wire of a given material at a definite excess of temperature is approximately directly proportional simply to the thickness of the wire.

(To be Continued).

COMPANIES' MEETINGS.

THE INTERNATIONAL CABLE COMPANY.

The annual general meeting of the International Cable Company (Limited) was held at the offices, 34, Nicholas-lane, E.C., on Thursday, December, 29, W. J. Thompson, Esq., in the chair. There were also present Baron Da Costa Ricci, Mr. Da Ricci, Mr. J. W. Adamson, Messrs. Gibbon, Pope, Holroyd, Surén, Dain, Quick, Captain Wood, Mr. Sydney Thompson, Mr. Fox, Mr. Macpherson, Mr. Bartlett, and others.

The CHAIRMAN said: I appear before you as the chairman of a company which had a very warm reception at its start. Now, we were quite prepared for opposition, as the many supporters of the existing companies were sure not to be friendly to our scheme, and certain parties thought themselves justified in casting ridicule upon it in the Press; but having been engaged in this project now myself some considerable time, I must acknowledge the courtesy which I have experienced from all concerned in it, and though some people have made strong remarks they never cast any reflection on the directorate, and I may even go further and say that had they looked through other coloured classes their verdict would have been with us. There is only one matter that I would further mention on this subject, and that is that some reference should be made to a remarkable letter which I think damaged this Company most seriously, and even at this time I cannot realise what the writer might have intended, or whether he really weighed in his mind what would be the effect of his words. The letter damaged this scheme; but you will hardly credit it that the writer was at that time a director, if not the chairman, of a syndicate who were anxious to promote this scheme. We shall now ask your opinion as to what you wish us to do in this matter in future. We hold the opinion that the proprietor of a single share in the company is as much entitled to his opinion as the holder of 100. Had we studied our own ease and comfort we should have retired as soon as we found the public held back. We had large promises from Liverpool and Glasgow which failed; but as there were large subscriptions from parties professedly anxious to see the scheme carried through, the directors feel they should not resign as long as there is any appearance of success. They determined, however, this, that unless they could be satisfied that there were sufficient funds to carry out the scheme in its integrity, they would not risk the money of the subscribers, although there were frequent requests to commence. Certain foreign subscriptions proving doubtful was another reason for over caution. Your directors have worked at their own personal cost, and hoped to the last, and our hope has not been abandoned. The promoters, on their part, met the different position most frankly, and consented to forego half their claims. A member of the board offered at his own cost to put himself in communication with his friends in Paris. He went over bringing the scheme to the notice of his friends. When there he made an arrangement with Count Dillon, and after this he went over at the request of the board to Portugal, and saw his Excellency Senor Aguiar, late Minister of Public Works, and obtained an important extension of the contract for the concession from twenty to forty years. There were minor concessions, and I may say you cannot too much thank him, though he requests his name may not be mentioned. It will also be in the recollection of some of you that the British Government invited tenders for a cable from Halifax to the Bermudas. As this was part of our scheme and would have been a key to our cables, to which we felt we might look, we entered into negotiations on the subject, and we have every reason to believe that if the British Government had not subsequently determined to defer the tender it would have been given to this company. Had it been so we should have been in a position to lay down our cable. However, the thing is not entirely dropped. An official from the General Post Office called last week on Mr, Sydney Thompson to know if the scheme was going on. If we had succeeded in this, we could have gone on and found funds sufficient for carrying out your entire scheme. Well, we have also had communications from America and Spain to work with the company, but until the main question is settled we feel it would be needlessly taking up time to consider these questions. At the present moment, the increased cost of copper is unfavourable, and that is one reason why we must consider, but on the other hand, there seems to be less desire on the part of the existing companies to continue the war of rates. Well, you must decide as shareholders what to do. Our position as directors has been anomolous. We always desired to go on if we could, and fairly and honourably. If the shareholders wish us to continue in office, I think we shall be willing to remain for six months. If on the other hand you come to the conclusion to close operations, we shall be prepared to resign and give the seven days' legal notice for meeting. We have the money subscribed lying at the bank at seven days' call, where it has been since we received it—excepting something less than £600 which have been required for expense of office, secretary, &c. The board made no charge, and as we have nothing more to add, I shall now be happy to hear your views.

After a somewhat warm discussion, during which the motion was made to wind up the company, and an amendment not to wind up the company, the amendment was carried, and, therefore, for the present, the company is not to be wound up.

A vote of thanks to the chairman concluded the meeting.

CITY NOTES.

Direct Spanish Telegraph Company.—The estimated traffic receipts of the Direct Spanish Telegraph Company for December were £2,004, against £1,782 for the corresponding period of last year.

Empire Telephone Company.—The customary notice has been given by the liquidator of a general meeting of this company on the 28th January, 1888, at 60, Queen Victoria-street, for the purpose of having the liquidator's accounts.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the past week amounted to £4,102, and those of the Western and Brazilian Company, after deducting the fifth of the gross receipts payable to the London Platino Brazilian, were £3,318.

Eastern Telegraph Company.—The traffic receipts of the Eastern Telegraph Company for December amounted to £57,703, against £52,823. Those of the Eastern Extension, Australasia, and China Company for December amounted to £38,908, against £40,539 for the corresponding period of 1886.

Great Northern Telegraph Company.—The traffic receipts of the Great Northern Telegraph Company for December were £21,600, making a total from January 1 to December 31 of £264,480, against £258,600 and £284,720 for the corresponding months of 1886 and 1885 respectively.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company for the half month ended December 31 were £2,826, against £3,089 for the corresponding period of 1886. The September receipts, estimated at £4,357, realised £4,453.

Carbon Trade.—We are requested to state that after January 1 the Globe Electrical and Engineering Company, of 7, Carteret-street, Westminster, will act as sole London agents for the Barnsley Carbon Company, of Barnsley, and will supply both carbon rods and plates from their London stores at the same price and terms as the Barnsley Carbon Company.

West Coast of America Telegraph Company.—The traffic receipts of the West Coast of America Telegraph Company for December were £4,300. The number of messages passing over the lines of the Cuba Submarine Telegraph Company during December was 3,925, estimated to produce £3,300, against 3,695 messages, producing £3,125, in the corresponding month of last year. The traffic receipts for September, estimated at £2,500, realised £2,494.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.	Dividend.		Name.	Paid.	Price. Wednesday
1 July	4%	African Direct 4%	100	98 to 100	1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105
12 Feb.	1/2	Anglo-American Brush E.L.	4	4¾	25 July	10/0	India Rubber, G. P. & Tel.	10	22
12 Feb.	2/0	— fully paid	5	4¼	28 Oct.	12/6	Indo-European	25	39
28 Oct.	7/6	Anglo-American	100	37½	16 Nov.	2/6	London Platino-Brazilian...	10	4½
28 Oct.	15/0	— Pref.	100	61¼	16 March ...	5%	Maxim Western...............	1	5-11
12 Feb., '85...	5/0	— Def.......................	100	14	15 May	5%	Oriental Telephone	11	⅜
29 Dec.........	3/0	Brazilian Submarine.........	10	12⅛x	14 Oct.	4/0	Reuter's	8	8½
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	3½	1⅜
28 July	8/0	Cuba	10	12½	28 July	12%	Submarine	100	135
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	97
14 Oct.	1/0	Direct Spanish	9	4	14 July	12/0	Telegraph Construction ...	12	39
18 Oct.	5/0	— 10% Pref.	10	9	1 July	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	8½	30 Nov.	5/0	United Telephone	5	11⅞
14 Oct.	2/6	Eastern	10	11⅛	......	...	West African	10	5
14 Oct.	3/0	— 6% Pref.	10	14¾	1 Sept.	5%	— 5% Debs.	100	93
2 Aug.	5%	— 5%, 1899	100	109	29 Dec.........	6/0	West Coast of Africa	10	5x
28 Oct.	4%	— 4% Deb. Stock	100	103	30 June	8/0	— 8% Debs.	100	114
14 Oct.	2/6	Eastern Extension, Australasia & China............	10	12⅛	14 Oct.	3/9	Western and Brazilian......	15	9
					14 Oct.	3/9	— Preferred	5½	5⅞
2 Aug.	6%	— 6% Deb., 1891	100	109	......	...	— Deferred..................	2½	3
1 July	5%	— 5% Deb., 1900	100	107	2 Aug.	6%	— 6% A	100	108
2 Nov.	5%	— — 1890	100	102	2 Aug.	6%	— 6% B	100	105
1 July	5%	Eastern & S. African, 1900	100	105	......	...	West India and Panama ...	10	...
30 March ...	6/3	German Union	10	9¾	30 Nov.	...	— 6% 1st Pref.	10	10
14 Oct.	0/6	Globe Telegraph Trust......	10	5⅝	13 May, '80...	...	— 6% 2nd Pref.	10	6½
14 Oct.	3/0	— 6% Pref.	10	13⅜	2 Nov.	7%	West Union of U.S.........	$1,000	125
July	5/0	Great Northern...............	10	14	1 Sept.	6%	— 6% Sterling	100	104

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Nov. ...	£39,000	+ £2,261
Brazilian Submarine	W. Jan. 4	£4,102	...	Great Northern	M. of Dec. ...	21,600	...
Cuba Submarine	M. of Nov. ...	3,000	+ £420	Submarine	None	Published.	
Direct Spanish.....................	M. of Dec. ...	2,004	+ 222	West Coast of America	M. of Dec. ...	4,300	...
— United States	None	Published.	...	Western and Brazilian	W. Dec. 23 ...	4,006	...
Eastern..............................	M. of Dec. ...	57,703	+ 4,880	West India and Panama	F. ½ Dec. 31 ...	2,826	− 263

Abbreviations: W., week ; F., fortnight ; M , month.

NEW ELECTRICAL COMPANIES, 1887.

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Shares.	Deposit.	Total Deposit.
Blockley Electric Lighting and Manufacturing....................................	£20,000	...	£5 0 0	...	...
Eclipse Electric Battery, Limited	100,000	£100,000	1 0 0	£0 10 0	£50,000
Electric Battery Brush, Limited	50,000	50,000	5 0 0	1 0 0	10,000
Extended Electro-Metal Extracting, Refining, and Plating, Limited	150,000	150,000	1 0 0	0 5 0	37,500
Jensen Electric Bell and Signal, Limited	100,000	100,000	1 0 0	0 6 0	37,500
Orient Electric Light...	5,000	...	250 0 0	...	...
Platinum Plating, Limited	60,000	59,100	1 0 0	0 5 0	14,775
Portland Electric Light...	45,000	...	5 0 0	...	...
Singapore, Straits Settlements, and Siam Electrial, Limited..................	60,000	39,000	5 0 0	2 0 0	15,600
South Metropolitan Electric Supply	250,000	...	10 0 0	...	...
St. James's Electric Light, Limited	50,000	50,000	5 0 0	2 0 0	20,000
Union Electrical Power and Light, Limited	500,000	125,000	5 0 0	2 0 0	50,000
Winfields, Limited..	160,000	120,000	5 0 0	3 0 0	72,000
Woodhouse and Rawson, Limited	200,000	105,000	5 0 0	1 0 0	21,000

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NOTES.

Garston.—The sugar refinery and docks of Messrs. Bostock and Co., Garston, are to be lighted by electricity. The Lever system is the one to be adopted.

Objection to Electric Light.—The Parisian actors complain that the substitution of electric light for gas in the theatre renders the stage so cold that they suffer.

The Grand Theatre.—Steps are already being taken for the re-erection of the ill-fated Grand Theatre, and it is anticipated that a new building, lighted entirely by electricity, will be finished by Easter.

Provisional Order.—Notice has been given, in accordance with the Electric Light Act of 1882, by the Liverpool Electric Supply Company for a Provisional Order. It is understood that the company intend to light a considerable part of Liverpool.

Photo-Electric Currents.—Dr. Moser finds that the electromotive force produced by the action of sunlight on chloride, iodide or bromide of silver plates, can be considerably increased by immersing them in a bath of erythrosin or some similar dye.

The Gramophone.—An improved apparatus under this name—apparently a combination of Edison's *phonograph*, Graham Bell's *graphophone*, the *phonautograph* of Léon Scott, and the perfected phonautograph of Charles Gros—has been constructed by Mr. Berliner, of New York.

Bradford.—It is said that the plans and specifications relating to the proposed electric lighting experiments in this town are to be submitted to Dr. J. Hopkinson, in order that he may give his opinion concerning them, and for this purpose an early visit to Bradford will be made.

Electric Light and Books.—Attempts are being made to prove that the electric light is more injurious in a library than gas. Of course, this is not so ; the effects of gas are ruinous to all good binding; the effects of the electric light are confined to the deepening the colour of paper made of wood fibre—otherwise it is harmless.

Fog and Smoke.—Three or four days of a London fog make one desirous of seeing Dr. Lodge's suggestion practically tested on a large scale. By the way, ought not the multitudinous overhead wires to have some remedial effect, or are the currents conveyed telephonically or telegraphically of such a character as not to produce any effect.

Electric Lighting in India.—Lord Dufferin's new Viceregal lodge at Simla is to be lighted throughout by electricity ; nearly 1,000 glow lamps will be employed. The circumstance is noteworthy, inasmuch as this is the first Indian palace so lighted. *The work is to carried out* by Mr. W. H. Massey, of Twyford, Berks, electrical engineer to Her Majesty.

Electric Lighting in Parliament.—It is estimated that to light the whole of the buildings connected with the House of Lords and the House of Commons, 5,000 lights will be necessary. At present only 500 electric lights are used, and these have given such general satisfaction that the impression exists that the necessary extension will be readily sanctioned.

The British Association.—Already steps are being taken at Bath to insure ample and comfortable quarters for the British Association, which meets in this town in September next. It is proposed to erect a temporary building adjoining the Assembly Rooms, to serve as a reception room. This building would be 150 or 160 feet long and 35 feet wide.

Cardiff.—The first of the bachelors' balls at Cardiff was given at the Cardiff Town-hall last week. The Assembly Rooms were tastefully decorated by Messrs. Trapnell and Gane, and variegated lamps, illuminated by the electric light, furnished by the Anglo-American Brush Electric Light Corporation, encircled the room, adding greatly to the effective decorations.

School of Electrical Engineering.—We have received an illustrated pamphlet which may be said to be a prospectus of this school. It describes the work of the school, and gives the press and other notices which have been obtained. The school has now been in existence twenty years, and should therefore be well known to the members of the profession.

Book Received.—*Formulaire Pratique de Eléctricien*, by M. E. Hospitalier. This well-known book has been corrected to date, and is undoubtedly filled with exceedingly useful information for all electrical engineers. We find, for example, that it contains mention of the new Kapp machine specially designed for use with transformers, giving a tension of 2,000 volts.

The Electric Light for Bournemouth.—The scheme laid before the Bournemouth Commissioners, by Mr. Andrews, the Town Surveyor, for the illumination of the gardens, the pier, and a portion of the town, by utilising the spare energy at the refuse destructor, has received strong support at the hands of Mr. W. Lynd, M. S. Tel. E. and E., who has written on the subject at considerable length in the Bournemouth paper.

Bute Docks, Cardiff.—Further information as to the lighting of these docks is to hand, and we find that the arc lights are being installed by Messrs. Crompton & Co.—not the Brush Co. as was originally reported. The scheme of lighting has been prepared by Sir W. Lewis and Mr. Hunter, the engineer to the docks, and a part only as yet of the

scheme is being carried out, as we say, by Messrs. Crompton & Co., under the supervision of Mr. W. H. Massey.

Cheltenham.—The Corporation have under discussion the question of introducing the electric light for illuminating a portion of the town. The members of the Corporation seem unanimous in their desire to introduce the light, but no decision has yet been come to, the immediate trouble being to decide if the subject shall be decided by the Streets and Highways Committee or by a special committee of the whole Council, with power to call in skilled assistance.

Testimony to Reckenzaun.—Mr. Wharton, President of the Electric Car Company, says that one of their new eight-wheel cars, with Reckenzaun motors and an Electric Accumulator Company's battery of 116 cells, ran a distance of 63 miles 211 feet in eight hours, with one charging of the battery. In the run there were 331 curves of 33ft. radius, 662 of 50ft., and 331 curves of 100ft. radius, besides 5 miles 2,390ft. of 5·8 per cent. ascending grades.

Germany.—Electric illumination has recently made great strides in Germany. According to a statement by Dr. von Stephan, the German Postmaster-General, it may be assumed that at the present time there are at least 15,000 arc lamps and 170,000 glow lamps in operation, which receive their light from 4,000 dynamos. If we reckon nine glow lamps and one and a half arc lamps for each horse-power, there are now over 30,000 horse-power employed in producing the electric light.

The Swansea Telegraphists.—The annual dinner of the Swansea Telegraph staff was held at the Albany Hotel a few nights since, every available member of the staff being present. The evening's proceedings were presided over by the superintendent (Mr. Edwards), and the utmost enthusiasm prevailed throughout. The usual toasts were proposed and responded to by Messrs. Edwards (superintendent), Desmond, Chislett, Johns, and Critchley, and subsequently an entertaining programme of vocal and instrumental music was rendered by various other gentlemen.

American Institute of Electrical Engineers.—The American Institute of Electrical Engineers has begun, in its monthly issue of *Transactions*, an index of current electrical literature, dating from October. The permanent value of such an index to electricians and the scientific public is apparent. The present instalment contains references to more than 300 distinct articles, cited from 18 papers and periodicals which are regularly indexed each issue, and from about 50 journals in all. Subsequent issues will comprise the leading electrical publications in foreign languages.

Indian Colliery Lighting.—The electric light has been introduced into the East Indian Railway collieries, at Giridhi, by the manager, Mr. Walter Saise, M. Inst. C.E., F.G.S., and marks the opening of a new era in Indian mining. The machine used is a 30-lamp dynamo, worked by a 2½-horse-power vertical engine, which is supplied by steam from the pit-winding engine boilers, so that the cost of working is practically *nil*. The lamps used are the ordinary incandescent. The miners are said to be delighted with the innovation, and go to their work with greater confidence than before.

Telephones for Buenos Ayres.—A company in Buenos Ayres has recently ordered the material for a complete system of telephones from the Société Générale *de Telephones at Paris*. *Annales Industrielles* states that over two thousand subscribers have been obtained, and the company proposes to erect a tower in the river, which will serve as a maritime telephone station. The harbour of Buenos Ayres is shallow, so that vessels are obliged to anchor several miles from the city. Telephone communication by means of a tower near the anchorage will be serviceable.

Temporary Lighting.—The occasion of the annual ball given to the staff of Thorpe Asylum, near Norwich, on the 6th inst., was this year made especially agreeable by the lighting of the hall by means of incandescent lamps, giving 4,200 c.-p.. The motor driving one of Messrs. Paris and Scott's C-type No. 2 dynamos was a rotary engine brought out by Messrs. Sturgess and Towellson, of Norwich. Motor and dynamo were coupled together and bolted to a cast-iron bed-plate 3ft. by 2ft., and running at 1,300 revolutions per minute. It was especially remarked how steady the light was, and how cool the hall remained even at the early hour of three in the morning.

Russian Train Lighting.—The plant used upon the trains lighted by electricity consist of a Crompton compound dynamo machine. At present the lighting takes place only on certain express trains, and in tunnels between Kieff and Odessa. There are three circuits of 2,000, 1,460, and 6,540 feet respectively. The rails are used for the return conductor, and the other wires are laid in a central tunnel between the tracks. Contact is made in each tunnel with the wire for that circuit by contact pulleys on the car axles. Each car has its own contact with the wire, so that all complicated connections of coupling a train are avoided. The train may stop while in the tunnel and the system will continue to operate. The company has applied the system to seventy-four cars, and they report that the expense of the system is less than one-third the cost of gas.

Theatre Lighting.—In another column we treat this subject at some length in an abstract of a paper by Dr. G. Sous; but we may here point out that the paragraph industriously circulated by the gas interest is misleading. A contemporary says:—"On the occasion of the opening of Mr. Terry's new theatre in the Strand, we mentioned that the electric light had been fitted up in conjunction with gas all over the house. At the present time, in addition to this theatre, only the Criterion, the Savoy, and the Prince of Wales's, are lighted by electricity, so far as the stage is concerned. At the Haymarket the electric light is employed in the auditorium." The hasty reader would probably take this to mean that at the Savoy, &c., the electric light was not installed all through the house, but only partly, and that on the stage. Of course it is not so. For the above read—"the electric light is used throughout the house as well as on the stage."

Walker's Portable Miners' Electric Lamp.—Mr. Sydney F. Walker is introducing an electric lamp worked by a bichromate battery. It is made in two forms, a round one, in which are two cells of a bichromate-carbon-zinc battery, and an oval one, which has three. The cells are made in a particular form, the carbon itself being the containing vessel. On one side is a strong lens, faced by a parabolic reflector, the two being held by a strong brass cylinder attached to the outer case, which is also of brass or copper. The cells contain the usual porous cells and zincs, and are closed by an india-rubber pad, above which the connections are made in a simple and efficient manner. A second pad of india-rubber is placed above this, and is

retained in its place by the cover, which is held by screws or a lock, as desired. A stout handle by which to carry the lamp surmounts the whole. The smaller lamp weighs 5lbs., and is said to give, for 10 hours, a light sufficient to read ordinary newspaper print at 6ft. from the lamp. The cost of renewing the chemicals used, the incandescent lamp, and incidental repairs, is stated to be not more than ¾d. per day for the small lamp and 1d. per day for the large one.

Electric Railways in America.—Electric traction is a recognised institution in America, and is rapidly extending. The Van De Pôle system is in use at Windsor, Ont., where two miles of line are in work with two cars, costing four dollars per day for sixteen hours. The steam power is rented. At Detroit, Michigan, there are also 2 miles of line, but these are only worked for 8 hours per day, at a cost of six dollars. Steam power here too is rented. At Appleton, Wis., water power is used. Here there are 5 miles of line and 5 cars, costing per day $4.50. At Port Huron, Michigan, 5 miles of line with 5 cars cost $3.50 only, the motor power being natural gas; Scranton, Pa., has 4½ miles, with 7 cars, costing $7, coal dust being used; Binghampton, N. Y., has 5½ miles and 6 cars, costing $10, with rented steam; Lima, Ohio, has 4 miles and 6 cars, costing $4, crude oil being used; St. Catherine's, Ontario, has 6 miles and 6 cars, costing $4 with water power; Montgomery, Alabama, has 13 miles and 18 cars, costing $14 with water power; Jamaica, L. I., has 6 miles and 10 cars. The total line worked on this system is thus: 53 miles on which 73 cars are running, while 16½ miles of line to carry 26 cars are under construction, viz., Ansonia, Con., 3½ miles and 4 cars; Omaha, Neb., 7 miles and 10 cars, and Dayton, O., 6 miles and 12 cars.

Atlantic Cables.—On Monday the Tribunal of Commerce gave judgment in the action between the Pouyer Quertier Company and the Anglo-American Telegraph Company, ordering the former to carry out the conditions of its agreement with the Anglo-American Company. It will thus be understood that the Anglo-American Telegraph Company, and the other companies affiliated with it, have won a decisive victory over the French Atlantic Cable Company. Originally the French company was started in antagonism to the English companies, but subsequently joined the "pool," breaking its agreement when the English companies seemed hard pressed by other competitors. The Anglo company instituted proceedings in the French Courts against the Compagnie Française, and the case was tried before the Tribunal of Commerce, the Compagnie Française being condemned on all points. They were ordered to pay damages amounting to 2,000 francs per day since they broke out of the "pool," and were further ordered to resume at once their contract with the cable companies. This means that, besides paying a very large sum to the "pool" companies, the French company will be compelled to withdraw from the Mackay-Bennett combination, and the "pool" companies thus regain a card which will assist them to force their adversaries' hands. However, the position of the Anglo-American Company is strengthened more because of its £1,000,000 reserve than because of any "pool" combination.

Lectures by Mrs. Ayrton.—A course of elementary lectures on electricity is announced to be given by Mrs. Ayrton, at 2, Upper Phillimore Gardens, on Jan. 17, and the five following Tuesdays. Mrs. Ayrton is a Graduate of Girton College. The syllabus of the lectures is as follows:—Jan. 17—*What Electricity can do for us.* (1) In our Households—Lighting, ringing bells, winding clocks, working machines, such as sewing, boot-cleaning and plate cleaning machines, telephony. (2) Out of Doors—Lighting large spaces, fire alarms, driving tricycles, cabs, tramcars, trains, launches, transporting goods. (3) In our Manufactories—Electro-plating, electro-typing, purifying metals. Jan. 24—*The Different Ways of Obtaining a Supply of Electricity.* Electricity among the Greeks. Galvani and Volta's discovery of the Electric Current. Galvanic Batteries. Energy—its different forms. The Conservation of Energy. The purposes for which Galvanic Batteries are economical—bells, signals. Jan. 31—*Faraday's Discovery—How to Produce Large Currents.* Electric pressure or potential. The difference between a good Conductor such as copper, and an Insulator such as gutta percha. Importance of good insulation to prevent accidents and waste. Lighting of the Grosvenor Gallery, St. James's Hall, &c., by the Grosvenor Gallery Electric Supply Association. The distance through which large currents can be sent. Deprez's Installation 37 miles. The storage of Electric Energy. Feb. 7—*Electric Lighting for Houses.* Incandescent Lamps—how they are made. The cost of lighting (1) a dinner table, (2) a ball room, (3) a house with incandescent lamps for one evening. The cost of lighting a house permanently with incandescent lamps. The Electric Lighting Act—How it has impeded the use of Electricity in England. Feb. 14—*The Physiological Effects of Electricity.* Galvani's Experiment with the Frog. Need for scientific precision in the application of Electricity to the cure of Disease. An Electric Hospital. Why Lightning is dangerous. Why Trees should be avoided in a thunderstorm. Lightning Conductors—worse than useless unless properly constructed. Points to observe when they are put up. Feb. 21—*Transmitting Messages, Music and Song by means of Electricity.* The Telegraph. Submarine Cables. The Telephone. The Microphone or Sound Magnifier. The Phonograph. Seeing by Electricity—can it be accomplished? The Future of Electricity.

Italian Military Preparations.—"Captive balloons for the Italian army in Abyssinia have been made in Paris under the supervision of Count Pecori Gerardi, director of the Italian aeronautic service. They are lighter than those hitherto used for purposes of military reconnaissance, being only 331 cubic mètres in volume instead of 500, and having a diameter of eight mètres. This reduction of size renders it unnecessary to have a steam engine to work the windlass on which the rope holding the balloon captive is wound. Six hundred men are sufficient for the purpose; and in case of need even the windlass may be dispensed with. [The correspondent of the *Globe*, who is answerable for this, does not say how six hundred men are going to work on the windlass.] Count Pecori Gerardi has also obtained a balloon in England, which with a volume of 180 cubic metres can raise an observer 500 metres high. It is made of goldbeater's skin of great strength, the net and rope being of silk, and the car weighing only two to three kilogrammes. The use of the telephone to speak from the car to the ground, or even to the quarters of the commanding officer, by reducing the number of observers, has tended to diminish the size and weight of captive military balloons. Count Pecori Gerardi has, in addition, adopted a small balloon of 50 cubic metres for signalling at night, by means of electric incandescent lamps, placed outside the balloon and in front of a reflector. This mode of fixing the lamps has been preferred, because the shell of the balloon, though translucent, is not very clear, and would cut off a great part of the light were the lamps enclosed within it, as is sometimes

done. A Morse key to 'make' and 'break' the current is part of the outfit; so is an aspirator to transfer the gas from one balloon to another. The gas is made at Naples and sent to Massowah in light steel tubes, each containing 4,000 litres in a volume of 32 cubic metres, and at a pressure of 125 atmospheres, the tubes being capable of withstanding a pressure of 220 atmospheres. These tubes will be carried on camels in the desert tracts and on mules among the mountains. The weight of the tubes necessary is less than the weight of zinc, acid, and water requisite to supply the gas by chemical means on the spot. It is expected that the balloons will not only be useful in Abyssinia for purposes of strategy, but also in disconcerting the enemy." Is not the signalling arrangement here described due to Eric A. Bruce?

Electrolysis in Sanitary Matters.—According to the article in the *Standard*, "electricity, which has served so many purposes in science and in the Arts, now promises to rescue civilisation from one of the most pressing difficulties which beset it. The Metropolitan Board are about to expend a sum of nearly, or quite, a million sterling in purifying the London sewage, so that the Thames shall be delivered from its present state of pollution. The process to be employed is of a chemical nature, and enormous works for the purpose of carrying out the project are in course of construction at Barking, to be followed by others of a similar nature at Crossness. At this juncture a plan of an entirely novel character is being perfected, which has the appearance of dealing successfully not only with the whole sewage problem, but also to a large extent with the question of the water supply of towns. The plan has been devised by Mr. Wm. Webster, F.C.S., son of the well-known contractor, who has had so large a share in executing the drainage works of the Metropolis. For certain reasons connected with the Patent Office, it would not be fair to the inventor to enter at present into all the details of his process, but certain results can be stated which will establish the importance of the undertaking. A current of electricity, produced either from cells or from a dynamo, is sent into the sewage, the transmission being effected through metallic electrodes. Instead of casting chemical ingredients into the sewage, the inventor adopts the plan of creating his chemicals in the sewage itself, by the action of the electric current on the electrodes and on the sewage. The effect is curious, and it is well seen when the liquid is exposed to view in a glass vessel. An inky fluid, obtained from the Deptford pumping-station of the Metropolitan Board, has all its particles set in a circulatory motion by the electric current, a kind of procession taking place from the top downwards and from the bottom upwards. The sum total of the movements consists in landing the suspended particles at the top of the liquid, thus exactly reversing the usual chemical process, which sends everything down in the form of a precipitate. The upward action is due to the presence of certain gases, at first extricated by the electric current, and afterwards mingling with the organic matter so as to give buoyancy to the latter. By agitating the liquid, the gases can be sent off into the air, and the solid particles will then descend to form a precipitate, showing no tendency to permeate the fluid as before. But, as will be shown presently, there is no need to effect this precipitation. So prompt is the effect of the electric current, that in the space of twenty minutes a volume of opaque sewage becomes perfectly transparent, except at the top, where the organic matter collects in a semi-solid form." It will be seen from the above that if the effects produced are the same on a practical scale as they are in the laboratory, it is possible that the discovery may lead to increased activity in the construction of dynamos and similar apparatus.

Station Lighting in America.—Among the papers contributed to the International Railroad Congress at Milan was one by Mr. G. W. Blodgett, Electrical Engineer of the Boston and Albany Railroad, from which the following data are taken relating to electric lighting by that company at East Boston:—"Brush lamps of 2,000 nominal candle-power are used. In the buildings they are placed 14ft. high, which was the greatest height which the construction of the buildings permitted. Out of doors the height is 24ft. Although there are 48 lamps, only 36 can be operated at the same time, which is the full capacity of the dynamos. Electric light is used only when the number of lamps needed is nearly the capacity of one dynamo; that is to say, 18. The cost of the electric apparatus at East Boston, in place, was as follows: Buildings, $3,116.12; 60-horse-power engine, in place, $1,737.10; shafting, pulleys, &c., in place, $364.29; belting, $412.30; two Brush No. 7 dynamos, $4,000; 44 lamps, with two sets of carbons, $3,520; two regulators for the dynamos, $250; wires, insulators, telegraph poles and cross-arms, and labour in setting up the machinery, lamps and wires, $1,322.75; total, $14,722.56. The cost of operation during the year ending Sept. 30, 1886, was $2,277.34, or $7·28 per day, or 20 cents per lamp per day, assuming 36 are used. The average daily use is about 10 hours for the whole year.—At Boston the passenger-station, train-house and yard are lighted by 33 arc lamps and 12 incandescent lamps. There are two Brush dynamos of 16 lamps each, and as they are run at a speed of 825 in place of 750 turns per minute, 18 lamps can be used instead of 16. They are placed at a height of 12ft., except 5, which are about 24ft. high. The cost of the apparatus, not including the engine or boilers (which are in use by the repair shops) was as follows: Two Brush dynamos, $4,000; 33 double arc lamps, $2,640; 2 single arc lamps, $120; 2 automatic regulators for the dynamos, $250; wires, insulators, fixtures, &c., and work of setting up the apparatus, not including the main shafting, &c., $1,206.47; total, $8,216.47. The cost of operation for the year ending Sept. 30, 1886, was $6,465.11, or $184.72 per lamp per year, or 50.6 cents per lamp per day. The cost per lamp per hour under these conditions was about 6 cents. The cost of power furnished by the motive-power department is $2.50 per day, besides the wages of the engineer. Carbons cost about 80 cents per day; oil-waste, &c., about 3 cents per day. The cost of repairs to 5 Brush machines during the 6½ years of use has not been, it is estimated, more than $150. Neither a lamp nor dynamo has yet been replaced nor sent to the factory for repairs. All such have been made by the men in charge of the apparatus. These installations were the first by a railroad company in New England, if not in America, and are still the most extensive. At Worcester the passenger-station is well lighted by 20 arc lamps, placed about 15ft. high in waiting-rooms, and 24ft. in the train-house. The cost is about twice as much as formerly paid for gas (which was never satisfactory), but several times the amount of light is obtained. The cost is 70 cents per lamp per night. It costs about the same at Springfield. At Pittsfield the electric light company light the passenger-station for the same price formerly paid for gas—about $1,400 per year."

The Vienna Opera Lighting.—The *Glasgow Herald's* correspondent, writing on this subject, says:—"It will be remembered that some weeks ago the Vienna Opera House

was closed by order, and remained shut for several days, owing to alleged defects in the arrangements for the electric lighting. This was no small event, and it excited passionate discussion, as the court officials, who have the imperial theatres under their management, sought to throw on the English contractors (the Imperial Continental Gas Association) the whole blame for what had happened. Those conversant with the facts were quite aware that the people really to blame were the incapable court officials, and this has now been brought out by the report of the scientific experts who have had to investigate the whole affair. The story offers so curious an illustration of the treatment which English companies have to suffer at the hands of Austrian bureaucracy that its details ought to be noted in England and Scotland, the more so as Austrian officials, when anxious to attract British capital for public works, are generally disposed to make all the preliminaries of negotiation so deceptively smooth that investors are lured on till they have passed the point at which withdrawal is convenient or possible. In the case of the British company which lights Vienna with gas, the acceptance of the contract for lighting the two Court theatres by electricity was a distinct favour which the company confessed no other company could or did offer such advantageous terms. The company has a large staff of *employés* and workmen, and an experienced staff of inspectors, and it possesses in Mr. Herbert Lindon, its general manager, an administrator of first-rate ability, with a thorough knowledge of Austrian ways. All this was recognised by the Court Intendancy, and as usual the first part of the business about the contract glided as on wheels. Once the contract had been signed, however, one thing after another began to be stipulated, so as to enable this and that official person to secure pickings at the expense of the contractors. Eventually Count Taaffe, the Austrian Prime Minister, himself insisted that the boilers at the Central Electrical Station should be of Austrian make. The English engineering contractors, Crompton & Co., of Chelmsford, had been about to order the boilers from a Glasgow firm (Babcock & Wilcox), but in deference to Count Taaffe the designs for the boilers were sent to the Austrian firm of Witkovitch, which is financed by the Rothschilds. The result was that six boilers were put in, which began to crack after two months. A Commission was summoned, reported the boilers to be dangerous, and ordered the closing of the opera. On this a furious outcry was raised against the English Company, the firm of Witkovitch declaring that the fault lay in the design of the boilers, not in the materials of which these were made. The whole matter was then referred to a commission of arbitration composed of Austrian experts, and these have now thrown the whole blame on the Witkovitch firm, which is proved to have manufactured the boilers in the most clumsy way with worthless iron. As a result the Witkovitch firm will have to pay all the expenses for closing the opera (3,000 florins a night for 10 nights), besides the cost of putting in new temporary boilers and buying a set of six new permanent boilers. These have been ordered from Babcock and Wilcox, of Glasgow." We have previously given the true facts of the case as regards the faulty boilers, yet it seems but just that the above information on what might well be termed the business proceedings, should be as widely known as possible.

Telephony over Long Cables.—Mr. T. D. Lockwood, in a note contributed to the discussion of Mr. Cuttriss's paper before the American Institute of Electrical Engineers, refers to the possible practicability of telephonic transmission over long submarine cables; and although his conclusions are those of every thoughtful electrician, they may be given for the sake of those whose knowledge of telephony is derived from experience in towns or on comparative short overhead lines. Mr. Lockwood says:—"You are all aware that in telegraphy it has been found possible to clear cables of charges by sending after each impulse of definite direction a clearing impulse of opposite direction, by which the static charge of the conductor was neutralised and the line cleared for the transmission of a second signal, The first idea regarding the transmission of telephonic or voice currents over submarine cables is in favour of its practicability; for it may be argued, since the foregoing practice aids the transmission of telephonic signals, and since telephonic currents, as usually transmitted, consist of a series of rapid alternations, why have we not here just the conditions of success. The truth is we have not, for in telephony the changes occurring are infinitely *too* rapid. They cannot serve the purpose of clearing the line; they rather serve the purpose of blocking the line, for the successive and consecutive impulses of opposing direction succeed one another so swiftly that they practically neutralise one another. Take, for example, the magneto telephone. It is well known that the currents generated by this instrument when used as a transmitter are alternating, and follow one another with extreme rapidity, so that for a long time it was thought that they were so infinitesimal as to be immeasurable. Suppose we have a fine galvanometer, and telephone through it. We see no deflection, but not because the current is so small, but because the plus currents succeed the minus currents of like potential and strength so fast that the needle cannot respond, and therefore does the next best thing and stays at zero. Let us now consider the battery transmitter and induction coil. A moment's consideration will show us that we have a close analogue to the operation of the magneto telephone. For though it is true that in the battery transmitter the action of the diaphragm merely varies the resistance of the circuit, and consequently the *strength of current correspondingly but in inverse* ratio, yet it is none the less true that the use of the induction coil develops currents in the secondary circuit and line which are alternating, because caused by the successive rise and fall of current in the primary circuit. Consequently these currents are subject for long circuits of high capacity to the same drawbacks as those of the magneto telephone. We have then at present only one other alternative method, namely, the plan of including the battery and transmitter in the main line, and allowing the transmitter to vary a permanent current flowing in the main line, thus dispensing altogether with the coil. But this also is impracticable, because the very small proportion of variation in the total resistance of such a circuit, cannot develop fluctuations of sufficient strength to satisfactorily influence a receiving instrument. I am therefore convinced that electric telephony—that is the transmission and reproduction of the human voice—will not, at least in the near future, be possible over long cables. Electro-static induction and the retardation and prolongation resulting therefrom is the reason. When I say *long* cables, I mean for example those over 100 miles long; and it would be difficult and not commercially successfully over much shorter distances. My conviction is that those who advertise the operation of telephones over Atlantic cables, either do not know what they are talking about; or knowing, wilfully make misstatements for prospective personal gain."

CONTINUOUS CURRENT TRANSFORMERS.

The problem of translating high tension continuous currents into those of low tension is just now attracting considerable attention in Germany and Austria, and the two leading electrical papers in those countries, viz., the *Elektrotechnische Zeitschrift* and the *Zeitschrift für Elektrotechnik* have in their current numbers articles on this subject. Both these articles are examples of how not to do it, and illustrate in a striking manner the old proverb that a little knowledge is a dangerous thing, especially if such knowledge leads to theorising on a very scanty experimental basis. The articles in themselves are therefore of very little practical value, and would hardly merit the attention of electrical engineers, but as the errors gravely expounded by our contemporaries at some length, as if they were sound scientific truths, might lead some of our readers into costly and useless experiments, we propose to give in the following a brief abstract of these papers, and to point out where the fallacy lies.

FIG. 1.

The writer in the *Elektrotechnische Zeitschrift*, which, by the way, is the official organ of the Berlin Society of Electricians, expounds the principle of continuous current transformation as if it were a new discovery. The system he proposes is to wind a Gramme ring with two circuits, each having its own commutator and pair of brushes, which are to be set at right angles to each other, so that when revolving the ring and keeping the brushes stationary, or revolving the brushes, the secondary coils should cut through the field produced by the primary coils. The idea that the field would necessarily be very weak and the self-induction in the commutating coils of the primary winding enormous, does not seem to have occurred to this

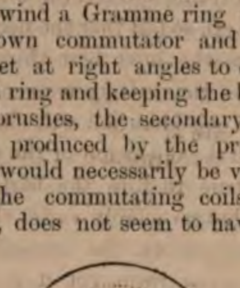


FIG. 2.

writer; and the fact that he could in sober earnest propose so absurd an arrangement is internal evidence that he has never practically tried it. Had he done so he would have found his primary commutator within a short time transformed into a mass of fused metal.

The system of Messrs. Jehl and Rupp, elaborated at length in the journal of the Vienna Society of Electricians, is not much better, though the details are certainly ingenious. The author starts with the consideration of a compound wound Gramme ring (Fig. 1), but recognising that the flow of lines, represented by the dotted lines, must necessarily be weak, owing to the great resistance of the air space, he improves upon this design by inserting a second ring or cylinder as shown in Fig. 2. To still further reduce the magnetic resistance of the air gap, the secondary winding consists of iron bars, and great stress is laid on the fact that owing to ring and cylinder being stationary no clearance is required—a great improvement over the transformer with a revolving armature. The primary winding is of the Gramme type, and placed on the ring, whilst the secondary winding is of the drum type and placed over the internal cylinder. To revolve the field a so-called distributing commutator (Fig. 3) is employed. It consists of a cylinder of insulating material into which are fitted metal strips of varying length. In our illustration the surface of the commutator is sup-

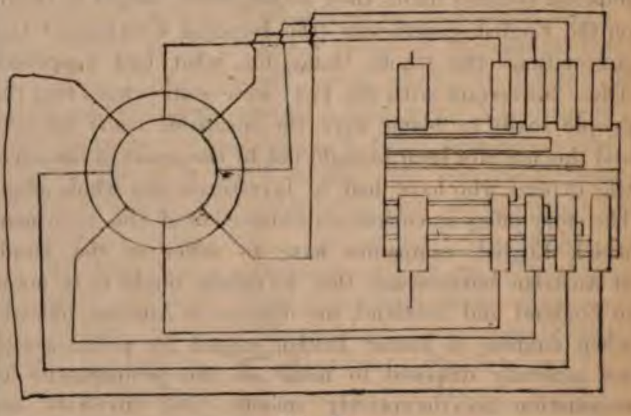


FIG. 3.

posed to be opened out to show all the strips. The wide brushes bring the main current, and each of the narrow brushes is in connection with one loop of the Gramme winding. When the commutator is revolved by an electro-motor the current is successively shifted from one brush to its neighbour, and the field created in the Gramme ring is

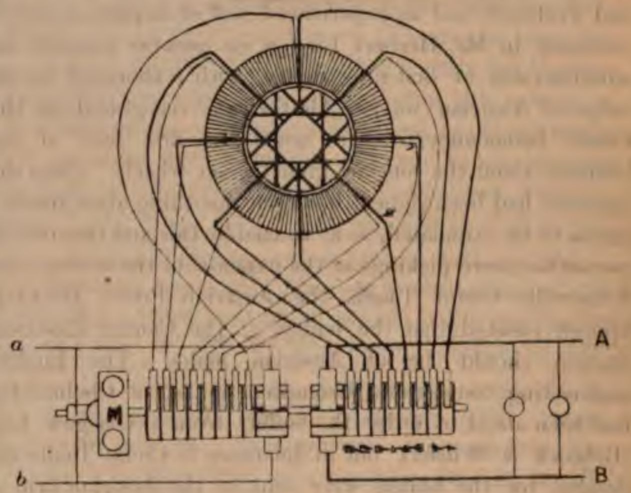


FIG. 4.

accordingly revolved. The secondary winding is similarly connected with another set of brushes placed at right angles to the primary set, but on the same commutator, an arrangement obviously possible because the metal strips are insulated from each other. In another arrangement, shown in Fig. 4, two commutators are employed, each con-

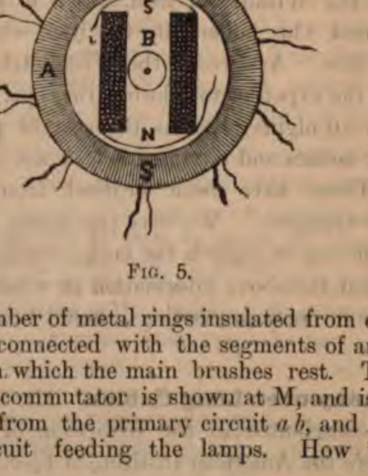


FIG. 5.

sisting of a number of metal rings insulated from each other, but severally connected with the segments of an ordinary commutator on which the main brushes rest. The motor revolving the commutator is shown at M, and is supposed to be worked from the primary circuit *a b*, and A B is the secondary circuit feeding the lamps. How this small

to be constructed for working under a pressure of bly 2,000 volts the inventors do not state. ggest, however, an alternative design (Fig. 5) in he formation of the motor is performed by the field magnet B revolving by the attraction of the g poles N S in the Gramme ring. The commutator this case be fixed to the spindle of the field magnet. ese designs the polar line of the secondary winding ht angles to that of the primary winding, and, con- y, the commutation in the coils of the primary takes place in the strongest part of the primary t is needless to say that under these circumstances ust be excessive sparking at the brushes and the ator would probably be burnt up in a very short

difficult to see why these Continental electricians ave devoted so much ingenuity on a system which ly very complicated but radically defective. The lly simple device originally invented by Gramme, pted by Messrs. Paris and Scott, of Norwich, is so apted for transformation of continuous currents need exists for going further a-field. There is no o block the way, and there are no unforseen es to face. The machine is simply an ordinary with two windings on the armature, and the fact mutation takes place in both windings on the same and in a part of the field where there are ly no lines, whilst the self-induction of one circuit es that of the other, makes the machine absolutely

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

studying the principles involved in the construc- dynamos, it is necessary for the student to obtain otions regarding the units by reference to which ency and output of such machines are computed. we speak of a current of electricity as if there actual flow of something through the conducting e, the real nature of the agency by which electrical na are produced has yet to be discovered. These na are correlated in a perfectly definite way, and t of electrical science is to formulate with com- of knowledge the correlation. But of the nature ricity, of the cause producing these correlated re are profoundly ignorant. We do not know thing actually flows in the conductor through current is said to be passing, though the analogy the flow of water in pipes and of electricity in rs is in many respects a close one. What we do hat the effects with which the electrical engineer e for their cause a common agency. When these re manifested, we conventionally ascribe their ap- to *electricity* or to an *electric current*, these ex- being little more than a confession of ignorance art regarding their real cause. Analogy justifies er in treating electrical phenomena *as if* produced nts in the conductors. For practical purposes we ume that electricity is a fluid actually flowing as a like water in pipes, but for practical purposes The idea is helpful to the student, the language of l science is based on it; but after all it is but a expression. There may be no current at all in luctor, but no harm is done if, while assuming the of a current, and treating our facts accordingly, ember that such treatment is adopted purely as a f convenience. Bearing this in mind, we proceed e the various electrical units employed by practical

antity.—With some of the effects produced by currents the reader is doubtless familiar. If a iron is brought near a conductor in which a current iron will be magnetised. If a suspended magnet ht into the vicinity of the conductor it will be . If the current is sent through a platinum wire r may be raised to a high temperature. Lastly, if luctor is a liquid it suffers chemical decomposition e current flows. The quantity of electricity flowing can be determined only from the magnitude of the effects produced. We cannot see electricity, nor can we measure it directly, but we can see the effects and measure the pull of a magnet, the force deflecting a needle, the heat generated in a wire, or the amount of chemical decomposition. Electrical quantity might be expressed in terms of either of these effects, but in selecting a standard method by which measurement can be made, it is necessary above all things that the apparatus employed shall be capable of easy reproduction. For this reason it is convenient to define the unit quantity of electricity in terms of the amount of chemical decomposition produced. If a current is passed between two silver plates immersed in a 25 per cent. solution of silver nitrate, one plate gains in weight from the deposition of silver an amount proportional to the quantity of electricity passing. This gain is independent of the size or shape of the containing vessel, and also independent of the size or weight of the silver plates. Manifestly a standard of this kind can be reproduced at any time, and the practical unit of electrical quantity has been defined as the *Coulomb*, which, in passing between two plates in a 25 per cent. solution of silver nitrate, will deposit on one of them ·017253 grain of silver.

2. *Current.*—The term *current* introduces into electrical measurement the idea of *time* A coulomb is a quantity, is therefore independent of time, and may take a year, a week, or a day, to pass through the conductor. Besides the unit of quantity, we require a unit rate of electric flow, or, more briefly, a unit current. Current simply means the rate at which electricity progresses along a conductor. The unit of current is the *Ampere*, which is defined as one coulomb per second. We speak more frequently of amperes than of coulombs, because generally we require to know the rate at which electricity is flowing at the moment of observation, and not the total quantity which has passed, say, after an hour or a day. It will be understood that by current in amperes is expressed the number of coulombs passing per second; thus, if we say the current is 20 amperes, we mean that in each second 20 coulombs pass through the instrument by which the measurement is being made. There exists between coulombs and amperes a relation similar to that existing between "gallons" and "gallons per second." The former is a quantity; the latter is not a quantity, but simply a rate of flow. Though in electrical measurements quantity is expressed in coulombs, rate of flow is not expressed in coulombs per second. The term ampere is employed instead, probably because rate of flow can then be expressed by one word instead of three, which saves the electrician's time.

The *direction of current* has been arbitrarily fixed with reference to the phenomena produced. It is said to flow in one direction or the other accordingly as a needle magnetised in a definite direction deflects to the right or left when occupying a particular position relatively to the conductor; or according to the direction of the magnetism produced in a piece of iron occupying a certain position in its vicinity; or accordingly as the silver is deposited on one or other of the two plates immersed in a silver bath. If the current flows through a conductor arranged to produce all these effects simultaneously, it will be found, on reversing the connections at the battery or other source of current, that all the effects are reversed. The magnetised needle is deflected to the opposite side, the direction of the magnetism is reversed in the iron, and in the silver bath the deposition is on the other plate. These facts justify us in assuming not only that electrical phenomena are caused by currents in conductors, but that these currents may be made to flow in either direction. Accordingly, with reference to silver deposition, we assume the direction of the current to be that of the silver in the bath. That is, the electricity flows towards the plate on which the metal is deposited.

(To be continued.)

ELECTRIC LIGHTING BY THE TOWER SYSTEM.

The use of high masts or towers for electric lighting purposes has not gained much favour with electrical engineers in England. Our towns, in fact, are not built so

as to permit of such a system being generally adopted, yet, perhaps, it might be found advantageous in many cases. Our nearest approach to American practice is, perhaps, in lighting docks and railway yards. We give below a description of the towers as used in Detroit, from our American contemporary *The Engineering and Building Record* :—

This question involves the following points :—

First.—A form of construction of towers that will require minimum horizontal space for base, be inaccessible to boys climbing, and offer least obstruction to view along the street.

Second.—Strength to resist high winds.

Third.—Ready means of ascending to the lights, so that an attendant may care for the lamps without breaking the circuit.

Fourth.—Perfect accessibility of all parts for frequent inspection and painting.

Fifth.—The proper height for towers in order to yield the best practicable results—*i.e.*, to enable the light to reach its effective limit without unduly robbing its immediate surroundings.

The system of electric lighting from towers is of very recent date. Their construction has been subject to gradual change and development.

At the outset a square pyramidal tower was most used, made with inclined posts at the corners, united by horizontal struts and braced both in the plane of the sides and horizontally. These horizontal braces prevented the ready arrangement and operation of an interior elevator, so resort was had to a triangular tower similarly braced on its exterior faces, but requiring no interior bracing. This left free space for an elevator, but, in order to insure strength, the tower was tapered from the top to the base, so that with an altitude of, say, 150ft., the spread at the base was about 28ft.

This formed no great objection where the tower could be located in a park or unoccupied public square, but to light a city or town these towers had to be located at street corners. It was found necessary, therefore, to have the tower span the street or a sidewalk, so that one corner of the tower might rest near the corner of the street, and the two other corners of the tower rest adjacent to the buildings. This was unsightly and inconvenient, as frequently in cities the space between the sidewalk and the building is occupied by vaults or openings, and tower foundations placed there would often be very much in the way, necessitating the shifting of a tower location from a point where it ought to be to some other locality where it is possible to erect it.

Again, with a pyramidal tower not guyed, the wind-pressure caused great strains, and required heavy members, and necessitated frequent adjustments and repairs. Assuming the same wind pressure per foot of height on the pyramidal tower as is permissable for the prismatic one, and that the former is not guyed, and that the latter is perfectly guyed, then for equal dimensions the unguyed tower would be strained at least four times as much as the other for the same wind-pressure.

The development and improvement of pyramidal and other forms of tower gradually led to that here illustrated.

It is essentially a triangular prism, 6ft. on a side, built in 17 vertical sections, each 8½ft. long, supported on a single base column and guyed at two points. The centre lengths of all sections are equal, and members, to a considerable degree, interchangeable.

The foundation is generally located just inside the angle of the curb at the street corner, and consists of a double platform of two-inch oak plank, laid crosswise, carrying a pier, three feet square, of hard-burned brick set in a mortar of hydraulic cement and coarse sand; the pier is capped by a stone, 3ft. by 3ft. by 6in., that receives the base casting, the latter secured by six 1¼th anchor bolts through the masonry, and bearing on an iron ring beneath the platform. A tubular column, 14ft. high, screws into the base casting and receives struts at the top, connecting it with the prismatic tower. A light elevator platform runs in the interior of the tower, and is carried by a single endless cable passing over a fixed upper sheave and a lower sheave attached to an adjustment lever, pivoted at the short end and counter weighted on the free long end; the outer part of the cable carries a counterpoise nearly balancing loaded elevator. Two stationary guide-cables pass through the car and are engaged by a clutch which holds the elevator stationary, and only permits ascent or descent when released by pressure of the occupant's foot.

The towers have suitable lower and upper platforms with railings, and mast and arms for the lamps. All the compression members are of best lap-welded tubing, screwed into connection blocks of first quality malleable iron, that have ribs to which are bolted the forked ends screwed to each end of all the wrought-iron diagonal rods.

There are two sets of four guys each: one leading from a point 17-ft. below the upper platform and the other from a point 34-ft. lower down on the tower. The guys are each $\frac{7}{16}$in. galvanized wire cable, connected by a turnbuckle to an eye-bolt in an oak post 14in. square by 15ft. long that is set virtically 6ft. in the ground at about 150ft. from base of tower and receives two guy ropes in the same vertical plane. The iron-work is painted one coat of asphaltum, and the posts two coats of lead.

The towers are erected by first putting together the top section, then hoisting up and building on the next beneath it, and so on until completed. The weight of a complete tower, elevator, &c., including guy ropes, is about 7,200lbs.

The entire wind surface, including lamps, hoods, and mechanism, is calculated at 83 square feet, but this should probably be increased 50 per cent. for oblique and indirect exposure.

This form of tower has been subjected to terrific storms. At Evansville, Ind., twelve of them were subjected to three cyclones, one of which destroyed large numbers of houses, barns, and shops, and, in fact, demolished some of the heavy business blocks in the vicinity of the towers. The towers were not injured in the slightest degree. The other storms were likewise very destructive of other surrounding property. They have withstood very severe storms at Detroit, Mich., were 122 of them have been in service for four years. None of them have ever sustained the slightest injury, nor have they required any repairs; not even a bolt or nut has required tightening or adjusting since the towers were erected.

In the matter of the proper height, exhaustive experiments show 150 feet to be most satisfactory. Increasing this height impairs the illumination near the foot, and does not perceptibly increase the total lighted area, while diminishing this height diminishes the illuminated area and affords unnecessary brilliancy at the base. By reason of very lofty buildings in the immediate surroundings, a height of 175ft. might be in some instances desirable.

The towers should, so far as practicable, be arranged in a triangular system. The distance apart in business sections may be 1,200 to 1,500ft.; in the best residence sections, such, for instance, as may be found in Detroit at a distance of half to three quarters of a mile from the business centre, the towers may be 2,000ft. apart, and in the less densely populated sections and suburbs, they may be 2,500 to 3,000ft. apart. Thus at Detroit, Mich., 21 miles of territory, having about 4,000 street intersections, is thoroughly and brilliantly lighted by 122 towers, and there are no gas or naptha lights within the corporation limits.

In a general way, towns of three to six thousand inhabitants, occupying, say, a square mile of space, may be thoroughly lighted in every quarter by seven towers, one at the centre and six at the angles of a hexagon, the towers being 2,000ft. apart.

So, also, an excellent illumination may be had by five towers, there being one at the centre and four at the angles of a square, the towers being 2,000ft. from the middle tower, and where greater economy is desirable there might be four towers, one at the centre and one at each of the angles of a triangle, and about 2,000ft. from the centre tower.

In all cases it is recommended that the towers should have but four lights of 2,000 candle-power each. The central tower might have six lights of 2,000 candle-power. More lights will not materially improve the effect at a distance from the tower, while a less number of lights will scarcely afford illumination sufficient in the vicinity of the tower

All spaces are lighted by the tower system—front yards, back yards, alleys, and streets; and in street-lighting alone the four lights on a tower will do the service which would require 16 to 20 lights, on poles, while the pole-lights will illuminate only the streets and not the yards and alleys.

A number of towers serve to produce an atmosphere of light so blended in every direction as to neutralize the shadows, so that dense shadows exist in no quarter, giving the effect of moonlight over the entire area.

The Detroit Electric Tower Company was the pioneer in this work, and has profited in the construction of this tower by a very expensive experience. It has erected a large number of pyramidal towers in eighteen or more cities throughout North America, but since it produced this new type of tower here illustrated, based upon its large experience, it has urged them to the exclusion of all other styles, and has already erected them in Detroit, Mich., Evansville, Ind., Fond du Lac, Wis., La Crosse, Wis., Lima, O., New Orleans, La., Indianopolis, Ind., Owensboro, Ky., Council Bluffs, Iowa, and elsewhere.

It is stated that these towers, with 11,000 candle-power lamps, give an illumination at 200ft. and 1,500ft. equal to that from a gas-light at 7½ft. and 57ft. respectively, assuming the latter at the rather low value of 16 candle-power. As these results are proportionate to the inverse squares of the distances, they are probably nearly correct, except as influenced by special local conditions.

Detroit, Mich., is lighted from 122 150-foot towers, costing, at list price, $920 each, about $112,000; allowing 5 per cent. interest and 2 per cent. for painting, etc., this gives $7,840 cost of yearly maintenance. In 1886 the Electric Light Company's bid for furnishing lights was $87,300, making a total of $97,140. The gas companies made a competitive bid of $40,000 for the entire lighting, which was rejected.

For the drawing from which our illustration is made, and the data for the above article, and for courtesies extended to our representative while investigating the subject in Detroit, we are indebted to Edward W. Pendleton, Esq., Secretary Detroit Electric Tower Company.

ON SOME POINTS IN RELATION TO SECONDARY BATTERIES.

(Being a Lecture delivered to the Hanover Square School of Electrical Engineering, by DESMOND G. FITZ GERALD.)

According to Dr. Vander Weyde, Gantherot, in 1801, was the first to discover that the electrodes through which a voltaic battery has been discharged become capable of producing a reverse current. In the same year, Erman pointed out that the electrode connected to the positive pole of the charging battery becomes the positive pole of the secondary couple, and Ritter decomposed water by a current from polarised electrodes. In the two following years, Ritter constructed secondary batteries with plates of considerable size, and experimented with electrodes of copper, tin, zinc, lead, iron, bismuth, brass, silver, gold, and platinum. But, although five or six varieties of secondary battery were described in 1805 by Izarn, in his *Manuel du Galvanisme*, the credit of being the first to observe the peculiar properties acquired by electrodes of platinum has been given by Gavarret and others to De la Rive, whose paper on the polarisation of electrodes will be found in the *Annales de Chimie et de Physique* for 1825. We will now briefly illustrate these properties by an experiment.

(The lecturer here passed a current through an electrolytic cell formed of two platinum electrodes immersed in dilute sulphuric acid; then, obtaining a deflection on the galvanometer by connecting the electrodes to its terminals.)

The explanation of the effect observed, viz., that the anode condenses upon its surface a layer of oxygen, whilst a layer of hydrogen is deposited upon the cathode, was confirmed by Matteucci, who obtained the same effect by bringing one of the plates into contact with gaseous oxygen and the other into contact with gaseous hydrogen. The question had been previously elucidated by Grove, by means of his well-known gas battery.

Wheatstone, in 1843, constructed a secondary battery of very high electromotive force with negative elements of platinum coated with lead peroxide, and positive elements of potassium amalgam; and, ten years later, Siemens experimented with carbon plates coated with oxide of lead, to be converted into peroxide by the passage of a current. I have found, however, that this conversion cannot be effected by means of any form of carbon that I have tried, as the carbon itself becomes oxidised and disintegrated.

But it is to Gaston Planté, who first constructed his secondary battery in 1859, that the credit is due of having demonstrated the great advantages of lead, both for the negative and the positive elements of a secondary battery. These advantages will be to some extent illustrated by substituting strips of lead for the platinum strips used in our previous experiment, and noting both the degree and the steadiness of the galvanometric indication of the electromotive force brought into play by the passage of a primary current from one to the other electrode through an electrolyte of dilute sulphuric acid.

(Experiment shown. The deflection was reproduced after the couple had been short-circuited for a few seconds.)

An extended experience of Planté's battery brings into prominence an advantage equal in importance to that of a high and steady e.m.f. due to the layer of peroxide of lead formed at the surface of the positive electrode, which becomes the negative element of the secondary couple. It is that the positive element of this couple is insoluble in the electrolyte, and that the layer of sulphate of lead with which its surface becomes coated is—provided only that the layer does not become detached from the metal—readily and most economically re-convertible into metallic lead. The complete absence of the saline efflorescence, with which the users of zinc batteries are but too familiar, is worthy of high appreciation; but the fact that there is no waste or loss of material in working a lead secondary battery—the fact that a spongy lead positive may, after use, be restored to its original condition merely by returning to it, with a slight percentage in excess, the electrical energy it has developed—is one that can be duly appreciated only by those who are called upon to carry out electrical applications on an extended, and necessarily therefore, on an economical scale, and who have expended time and patience in the endeavour to effect the economical recovery of zinc converted into sulphate in a primary or a secondary battery.

Important and suggestive, and also very perfect as a laboratory appliance, the simple arrangement of Planté is ill adapted for general practical applications by reason of its comparatively low storage capacity, even after it has been "formed" by a lengthy series of successive charges and discharges. In effect a pound of lead in Planté's battery will give us only about four and a half watt-hours of electrical work; whereas we may at the present time obtain from 15 to 18 watt-hours for the same weight of metal more completely converted into "active material." It is stated that, so early as 1861, the late Prof. Kirchoff, with a view to remedy the practical shortcomings of the Planté cell, constructed batteries with alternate plates of spongy lead and peroxide. In 1863 the present speaker, being then editor of *The Electrician* (old series), insisted on several occasions upon the use of peroxide of lead, in contact with platinum or lead, for the negative element of the battery. The following extract from an article addressed to *The Student*, in the issue of that paper for March 20, 1863, may be of some interest, if only from the fact of its containing statements which may be advantageously corrected or amplified in the light of our present knowledge:—"The great power of the secondary combinations we have referred to is due to the presence of the peroxide of lead in contact with the negative element in these combinations. This substance, as was pointed out by M. de la Rive, surpasses even nitric acid in its affinity for hydrogen; and, for this reason, a couple constructed with a negative element of platinum, surrounded by a mixture of dilute sulphuric acid and the peroxide of lead, and with a positive element of amalgamated zinc in dilute sulphuric acid, is more powerful even than the couple of Grove. And, when lead instead of platinum is used for the negative element, the power of the couple is but little diminished."

This concluding statement, made by me a quarter of a

century ago, receives a *primâ facie* confirmation from the results obtained in the present day by our largest manufacturers of secondary batteries. I must admit, nevertheless, that it is altogether deficient in accuracy, as actually worded, being based upon insufficient experimental grounds. It is in great measure disproved by the two experiments now to be shown, which, when taken in conjunction with a third experiment also to be performed, lead to conclusions of considerable practical importance. (Experiment shown, as follows):—

We first take a strip of platinum and surround it with electrolytic peroxide of lead (obtained from worn-out E.P.S. negative elements) contained in a porous vessel and moistened with dilute sulphuric acid. This we oppose to a positive element of amalgamated zinc in dilute sulphuric acid. From the deflection indicated on the scale you will perceive that the initial e.m.f. of this miniature couple is not far short of two-and-a-half volts (2·469 v.). Let us circuit the couple through 10 ohms for a minute; on breaking the circuit you see that in a few seconds the spot of light moves nearly to its original indication. There is only a slight polarisation of the negative element, the effect of which soon disappears. But when we circuit the couple through 10 ohms for two or three minutes, the polarisation is much more marked, and the recovery is much slower. We have grounds for suspecting that platinum and not peroxide of lead—although the latter is a simple conductor—is the effective negative element of the couple. The electrolytic path to the platinum is of less resistance than that offered by the peroxide in its actual finely divided condition. Hydrogen is therefore set free at the platinum surface. Now there are two ways in which the hydrogen so liberated may become oxidised, and the platinum "depolarised." The hydrogen-coated surface may become the positive element of a local circuit in which the peroxide is the negative; in this case there must be a good conductive contact at one or more points between the elements of the local couple, and the depolarising action, as we shall presently see, is very energetic. Or the negative element may be depolarised by the layer of oxidising material in immediate proximity to it; in this case the depolarising action will cease when this layer has yielded up its oxygen—unless the negative element be moved so as to bring it in proximity to fresh oxidising material. Let us so move our polarised platinum negative: immediately the original deflection is reproduced: the element has become depolarised But, unless we can adapt to the cell some contrivance for continually moving the negative element, it is evident that we have not here the conditions under which a strong and steady current of electricity can be obtained. The physical condition—the coherence, the structure, the specific conductivity in mass of our depolarising agent, appears to be a matter of great practical moment. This is the first "point" to which I wish to direct your particular attention.

In our next experiment, I substitute for the platinum a strip of metallic lead, also surrounded with the electrolytic peroxide, and opposed to zinc. The deflection now obtained indicates an electromotive force of about 1·14 volt only. It is obvious that metallic lead, and not the highly negative peroxide of the metal, is here the effective negative. Note that the deflection is augmenting—a fact that, under the present conditions, is evidence of an increase of e.m.f., due to some action (a coating with sulphate) taking place at the surface of the lead. And here I have to impress upon you a second point, viz., that lead, in imperfect contact with peroxide of lead—*i.e.*, in contact only with detached particles of this conductor, and in contact also with the electrolyte—is the effective, but is very far from being an efficient, negative of a couple analogous to that which we are now testing.

Now, a question which suggests itself—and which I feel called upon to answer—is: How came I to state that "when lead instead of platinum is used the power of the couple is but little diminished?" My explanation is that, in the experiment from which I arrived at a too hasty conclusion, the peroxide was very closely packed around a sheet of lead which had become superficially peroxidised by being used as an anode in "charging up" the partly-reduced peroxide. Under these conditions I obtained results which certainly compare favourably with those we have just witnessed. Putting aside for the moment the question of the compactness of the peroxide, let us superficially peroxidise the strip of lead used in the last experiment It will now be a Planté negative element of very small capacity. It will, we know, give with lead (spongy lead, if any applicable current is to be supplied by the couple) an e.m.f. of about two volts; and with zinc, as we shall now see, it will give an e.m.f. nearly the same (about 2·45 volts) as that obtained with platinum surrounded by electrolytic peroxide of lead. Placing the peroxidised strip in contact with this material will of course neither increase nor diminish the initial effect. The question is whether, when we circuit the couple, the effect due to the superficial layer of peroxide upon the lead strip will be supplemented by the pasty mass of peroxide and acid contained in the porous vessel. I think you will not need to await the result of the experiment in order to answer this question. We have now circuited the couple through 10 ohms for little more than a minute; and, on breaking this circuit of low resistance the e.m.f. has, you see, fallen to about half its initial value (1·30v.). Nor will you have any difficulty in explaining this result. The effective negative of the couple is simply the peroxidised strip. This is in contact with electrolyte on the one hand, and on the other hand it is not in simple conductive contact with the mass of peroxide surrounding it, so that, when the superficial layer of peroxide has become exhausted, the negative is no longer an unpolarisable conductor, and no local circuit in which hydrogen is virtually the positive element is effective in producing depolarisation. Any slight effect of depolarisation that may occur is due to the detached particles of peroxide in immediate proximity to the negative element. And now I have to formulate a third point of practical importance in connection with secondary batteries, viz., that lead, coated with a superficial layer of dense peroxide, which latter is in contact with an electrolyte, and also in imperfect conductive contact with a further portion of peroxide of lead, acts as an efficient negative element only so long as the dense superficial layer remains unreduced. The necessity of a certain degree of compactness, or better, of coherence, in a mass of peroxide of lead intended either to act as an unpolarisable negative, or to be brought into contact with a conductor with a view to effect its depolarisation, has probably, I think, been already recognised by some, at least, amongst those whom I have the pleasure of addressing.

Continuing our brief chronological survey, it was in 1881 that Camille Faure constructed the secondary cell which, in consequence of Prof. Sir W. Thomson's letter in *The Times*, created such a stir in the financial if not in the scientific world. Faure's accumulator, as you are aware, was formed of flat or spiral plates of lead coated with red lead, which was kept in place by parchment-paper, and felt. The red lead—sesqui oxide of lead (Pb_2O_3) with excess of oxide—was, of course, reduced to spongy lead at the cathode and peroxidised at the anode in charging, the peroxide being initially in a somewhat compact form. That it was a mistake to use red lead instead of the protoxide at the cathode is very obvious, since it involved the electrolytic generation of considerably more than an equivalent of hydrogen to obtain the equivalent of spongy lead. But it is susceptible of demonstration—and the statement embodies one of the points I would wish you to note, though I do not purpose to give the proof at the present moment—that the use of red lead at the anode was a greater mistake still; for not only is the peroxide of lead already existent in red lead inefficient as a depolariser in comparison with electrolytically generated oxide, but the former, by diluting the latter, impaired its homogeniety and compactness, and thus rendered the working of the battery somewhat uncertain. In careful hands, no doubt, the Faure cell often gave results which, in the early portion of the present decade, were very encouraging if not surprising. Thus Profs. Ayrton and Perry obtained from it 6·78 watt hours per pound avoirdupois of lead employed in its construction. Other experimenters, however, obtained disappointing results, by reason mainly of a large proportion of the depolarising material being practically inert. That this should be the case will not, I think, appear to you altogether mysterious when it is

stated that the material in question was often found to be in the condition of a pasty mass. When it was ascertained, moreover, that a rotting of the felt occurred before the battery had been very long in use, the cells of Faure—undoubtedly the initial step in a great practical application of a scientific principle—entirely ceased to compete with subsequently devised forms of accumulators, of which the most prominent by far is the E.P.S. cell, with which you are already familiar.

I have no intention at the present moment of entering upon a critical consideration of the E.P.S. storage battery, and the points in connection with its working, which I will now mention, are perhaps already well known to you. These are, first, that the active material peroxide with a percentage of sulphate of lead in the negative grids should be, as I believe it now invariably is, not only very compact, but also possessed of a considerable amount of coherence, and of a structure which allows the plugs to become reduced to a lower degree of oxidation, with production of sulphate of lead, without contraction, and of the partly-reduced material becoming peroxidised without sensible expansion. And, secondly, that the metallic lead of the negative grids, when these are properly charged, becomes coated with a dense and almost impervious layer of peroxide—a protective layer which should always be maintained intact by avoiding a complete discharge of the negative plates and by keeping them fully charged, excepting, of course, when the battery is actually supplying a current.

By keeping this latter point in view, the positive as well as the negative element will be maintained in an efficient condition; the complete conversion of portions of the spongy lead into non-conducting sulphate almost impossible to reduce again to the metallic state is avoided; and the durability of the battery greatly extended. The principle of working was, I may mention, first pointed out and insisted upon by Messrs. Drake and Gorham. Our concluding experiments will have some bearing upon the E. P. S. as well as other forms of battery.

Reverting now to the point which was deferred—that of compactness in the peroxide as affecting its action as a depolariser, we need not take the trouble to ram the powdery peroxide tightly round the platinum or the superficially-peroxidised lead strip; for I have here a fragment of peroxide of lead in the compact and coherent form in which it is known as *lithanode*. By means of an ebonite screw, I will attach this fragment to the platinum strip, so that the two will be in contact, whilst the greater portions of the platinum surface is left uncovered. Now, if we employ this arrangement as the negative element of a couple, which portion of it will be the effective negative? or will both portions act as cathodes in collecting the current?

We might easily, if time allowed, demonstrate that the latter question must be answered in the affirmative; for, if we greatly extend the platinum surface, the internal resistance of the couple will be considerably diminished, and a similar diminution will occur if we extend the lithanode surface. But, now, will not the platinum surface become "polarised" by hydrogen, and thus our negative element be rendered inefficient? That is a question, I think you will see, which is dependent on the conductivity of the mass of peroxide and the perfection of the contact between it and the platinum. Let us test our compound negative opposed to zinc in dilute sulphuric acid.

The deflection indicated on the scale corresponds, I think, to 2·44 volts. But now I will circuit the couple for two minutes through 10 ohms. Will the e.m.f. fall to about half, or be diminished by 20 per cent. or less, think you? See, it has diminished only 2 per cent., it is rising, it has reached the original value within 1 per cent. We will circuit the cell for five minutes, whilst I am attaching a fragment of the coherent peroxide to our superficially peroxidised lead strip. Now I break the short circuit and you see the spot of light on the scale quickly reaches nearly to the original deflection. This means that the local depolarising circuit—from hydrogen layer to peroxide through the electrolyte, and from peroxide to platinum by simple contact—must be very energetic. This fact, of considerable practical import, may be taken as another of the points to which I would draw your attention.

I will now take as the negative of the couple the peroxidised strip with fragment of lithanode attached. Observe that the deflection indicating the initial e.m.f. is quite as high as in the former case. We will now circuit through 10 ohms for a couple of minutes. On breaking the circuit you will see that the deflection does not "pick up" quite so readily as in the former case. Still, the e.m.f. now indicated is nearly 2·4 volts. But now, if we circuit the couple through 10 ohms for five minutes, the effects of polarisation is much more evident. Our negative, moreover, begins to act irregularly. The peroxide on its surface becomes reduced, a local lead-peroxide couple becomes formed, and then the lead strip becomes coated with sulphate, and ultimately is corroded through and destroyed. The point for you to note in this case is that when you construct a negative element in which superficially peroxidised metallic lead is in contact with other peroxide, the latter only should be the effective negative, *i.e.*, the superficially peroxidised metal should be as far as possible prevented from making direct contact with the electrolyte.

You will no doubt be interested to know by what means —chemical and electro-chemical—peroxide of lead can be produced in a dense coherent and conductive form. I will therefore conclude by briefly describing the patented processes by which lithanode is manufactured.

(The lecture was concluded by a description of the process of manufacturing *lithanode*, embodied in patent No. 4671, 1885.)

THE THREAD-BRIDLED MICROPHONE.

The firm of P. Jenisch and Bœhmer, of Berlin, is introducing a new microphone in which the distinctive characteristic is that a more steady contact between the carbon pieces is obtained by means of the tension of a thread. A front view of the apparatus is shown in Fig. 1, and a section in Fig. 2. A ring of iron, E, is fixed to a plate, P, and

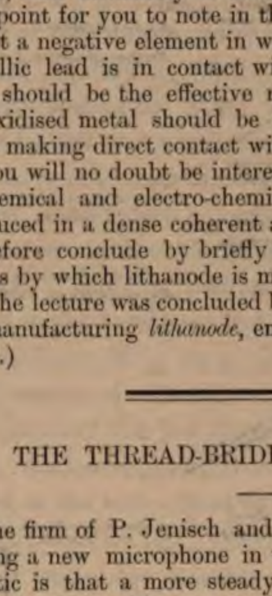


Fig 1.

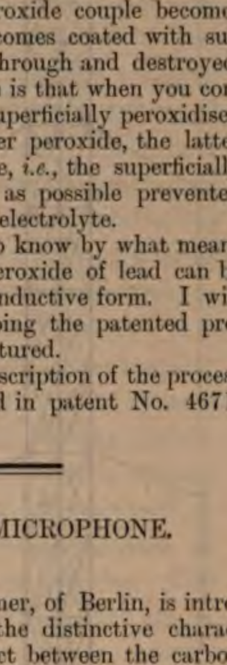
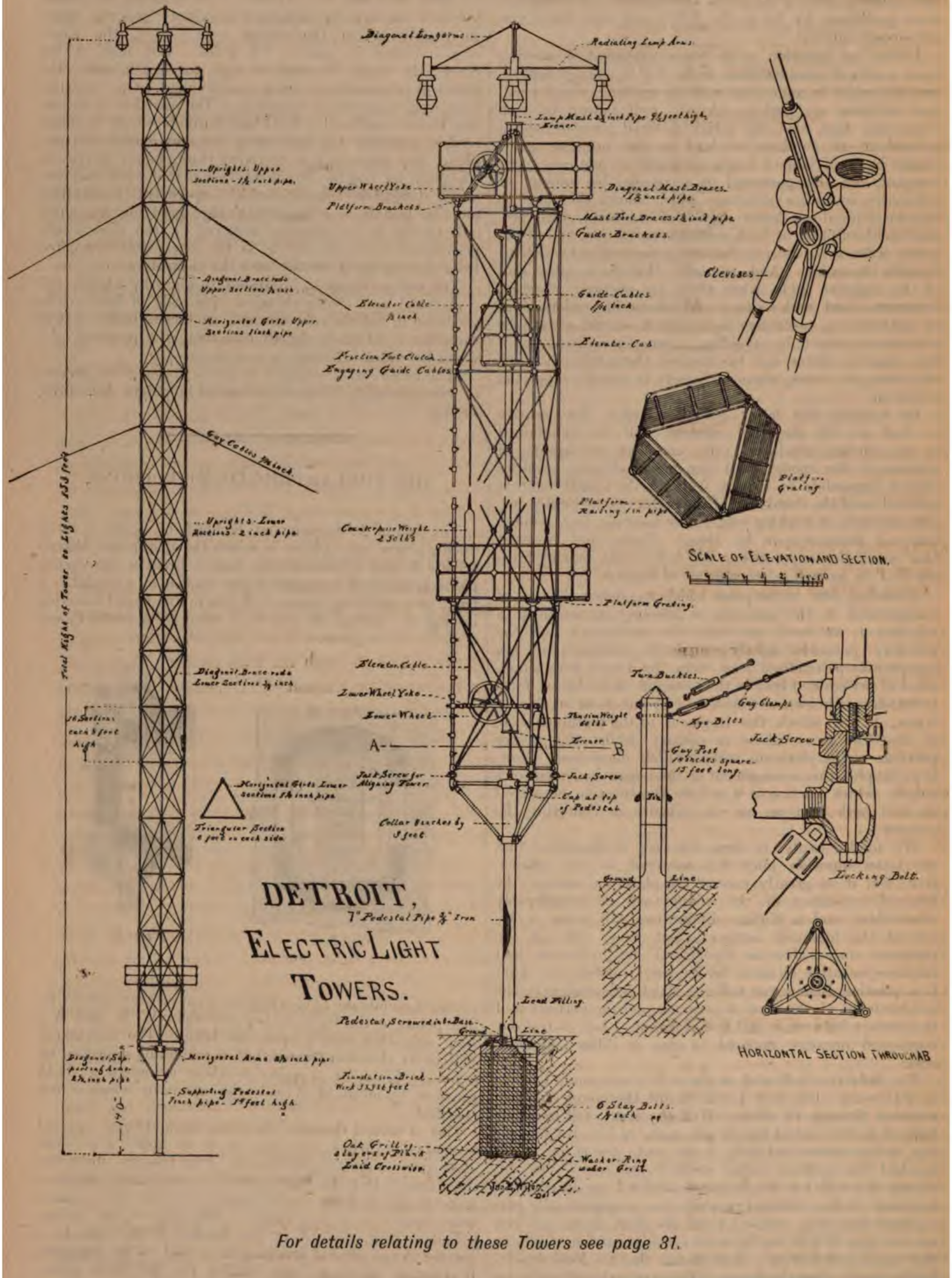


Fig 2.

carries a membrane, E, to which are screwed two carbons, K. The points of the three carbon cylinders, W, W_1 and W_2, bear somewhat loosely upon the latter. The instrument will act as thus constructed, but is materially improved by a novel system of applying to these cylinders a slight pressure by means of threads, the nature of which is not specified.

One or several threads (the figure shows two) are passed around the carbon cylinders so as to apply a pressure alternately in opposite directions. The pressure upon the membrane is thus diminished, and it consequently vibrates more freely, and can be arranged so as to give greater sensitiveness to the instrument. The play of the carbon cylinders being limited by the tension of the threads, a greater distinctness of articulation is said to be obtained. It is stated, moreover, that—unlike the Bell-Blake microphone—the instrument as thus constructed does not need re-adjustment from time to time when in use.

ELECTRIC LIGHT TOWERS.



For details relating to these Towers see page 31.

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NOTICE.

With our last number a fine steel engraved Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers (Institution of Electrical Engineers), was issued. In future numbers we shall give a series of Portraits of the eminent Electricians of this century, besides Portraits of Past Presidents of the Society of Telegraph Engineers. The next Portrait will be that of* WOLLASTON, *who flourished at the end of the last and the beginning of this century, and whose name has been immortalised by being applied to a particular form of battery designed by him. This will be followed by Portraits of* PROF. D. E. HUGHES, F.R.S., *and* SIR H. DAVY.

THE ELECTRIC LIGHTING ACT.

Parliament meets next month, and one of the questions with a special interest to Electrical Engineers is what modifications will the Session bring forth to the Electric Lighting Act, 1882? It is easy to be wise after an event, and to declaim unceasingly that the Act referred to was a mistake; but what we want now is a general concensus of opinion and agreement both as regards destructive and constructive legislation. The Act of 1882 has not proved an unmixed evil, but its good points have long been discounted, while its bad features are still cruelly operative. Broadly speaking the Act of 1882 affects not so much what may be termed luxurious lighting as what may be called commercial lighting. It does not stand in the way of lighting an hotel, a factory or a warehouse with isolated plants, but it does more or less stand in the way of lighting a street of shops, warehouses, or ordinary dwelling-houses, so that business in such lighting has been reduced to a minimum. The loss perhaps has not been so widely felt as it might have been had not many of the dynamo factories been fairly busy with ship lighting orders, factory work, and orders from abroad. Again, it must not be assumed that had the Lighting Act been perfect, central station lighting would have progressed in England at the same speed as it has in America. The conditions here are totally different to what they are on the other side of the Atlantic.

The reasoning of outsiders upon such a question as the Act of 1882 is, therefore, apt to be wholly fallacious. They have but a portion of the facts before them, and at best can but see through the glass darkly. It is a fact that those most conversant with the subject have worked persistently to obtain an alteration in the law. Writing in 1883, his book "On the Law of Electric Lighting," Mr. Cunynghame, in the very first paragraph, uses these words:—"The electric mania of 1882 has passed, and though the over-sanguine views then prevalent have been modified, enough has been done to show that electric lighting *is possible at such cost as is likely to cause an extensive demand.*" The italics are ours. The only people who can tell how far these words were justified are the managers of the companies and firms doing an electric light business. So far as our investigations reach the enquiries have been very numerous, the resulting work comparative small. The reason almost unanimously given for this state of affairs is the impossibility of doing the work required under the terms of the Electric Lighting Act.

We may then safely assume: that there has been and is an extensive demand, that the trade is able, and willing, nay anxious to supply the demand, but cannot do so because of the legal conditions and obligations arising out of the 1882 Act.

If this is a correct view of the case, the demand for a modification of the Act seems a just one. The action of Parliament in such cases as this should be to safeguard the public and to facilitate the development of

the industry. How far these interests may be opposing interests is perhaps a question open to discussion, yet it is difficult to see where the opposition comes in. That the development of electric lighting may be antagonistic to the gas interests will not be disputed, but surely the one industry is not to be supported at the expense of the other. The gas interest has the great advantage of being in possession, and no other advantage ought to be given to it by any Act of Parliament.

We have said that the work immediately to be done so far as the 1882 Act is concerned is both destructive and constructive. It is destructive to the extent that all the clauses of that Act—the whole Act if necessary—which act so disastrously upon the industry must be repealed; and constructive to the extent that the clauses or the Act substituted shall leave the industry free to develop in a natural manner. It is far more difficult for a man to walk with fetters on his legs and shackles on his arms than with legs and arms free; so it is far more difficult to obtain an industrial success under legal trammels than without them. As Swift might have said:—"Industrial progress is a continual navigation; if we expect our vessels to pass with safety through the waves and tempests of competitive interests, it is necessary to make a good provision just as seamen lay in store of beef for a long voyage." Electric lighting companies have been forbidden that "provision," so have failed as yet to make that headway they deserve.

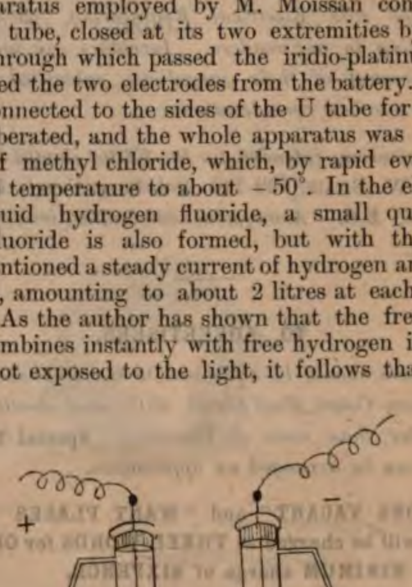
The experience gained by the trade since 1882 must point to certain requirements. Are they all agreed as to what is wanted? The first thing to do is to obtain such agreement at any rate upon all the principal points, while all minor points or details upon which agreement may not be easy should be relegated to the future. When agreement is obtained upon the fundamental principles, action should be taken to impress this agreement upon Members of Parliament. It will not be difficult to obtain one or even half-a-dozen members to put the requirements clearly before the House. And a Bill for the repeal of the obnoxious clauses, and their substitution by others as agreed upon by the trade, should be pressed through both Houses so as to become law as soon as possible. In all requirements it must be remembered that the best way to obtain what is necessary for the industry, is that the rights of the public should be respected. The motto might well be written—"A fair field and no favour."

ELECTRO-CHEMISTRY.

THE ISOLATION OF FLUORINE.

The isolation of the element fluorine, which has baffled the attempts of chemists for a great many years, has at length been effected by M. Henri Moissan in Paris. For several years M. Moissan has been examining the compounds of fluorine, and in his investigations has described the preparation and properties of phosphorus trifluoride, the oxyfluoride, and pentafluoride and arsenic trifluoride. He found in working with these bodies that the element fluorine was isolated when the fluorides of phosphorus were passed over heated platinum and when arsenic trifluoride was warmed; but it was found impossible to collect the gas which was isolated in sufficient quantity to determine its principal properties. The poisonous nature of arsenic trifluoride rendered it necessary to seek some other compound on which to experiment. Finally, he found that anhydrous hydrofluoric acid, rendered a conductor by means of potassium fluoride dissolved in it, was electrolysed by the current produced by a battery of 90 Bunsen element. Under these conditions, hydrogen is evolved from the negative pole, and a gaseous body, possessing new properties and of powerful chemical activity, is liberated at the positive electrode. The electrolysis of hydrofluoric acid had been previously attempted by Faraday and Gore in this country, but these investigators had not found a suitable method for rendering the solution conductive to the electric current.

The apparatus employed by M. Moissan consists of a platinum U tube, closed at its two extremities by caps of fluorspar, through which passed the iridio-platinum wires, which formed the two electrodes from the battery. Delivery tubes are connected to the sides of the U tube for collecting the gases liberated, and the whole apparatus was immersed by a bath of methyl chloride, which, by rapid evaporation, lowered the temperature to about $-50°$. In the electrolysis of the liquid hydrogen fluoride, a small quantity of platinum fluoride is also formed, but with the battery strength mentioned a steady current of hydrogen and fluorine is produced, amounting to about 2 litres at each electrode per hour. As the author has shown that the free fluorine liberated combines instantly with free hydrogen in the cold and when not exposed to the light, it follows that the gas

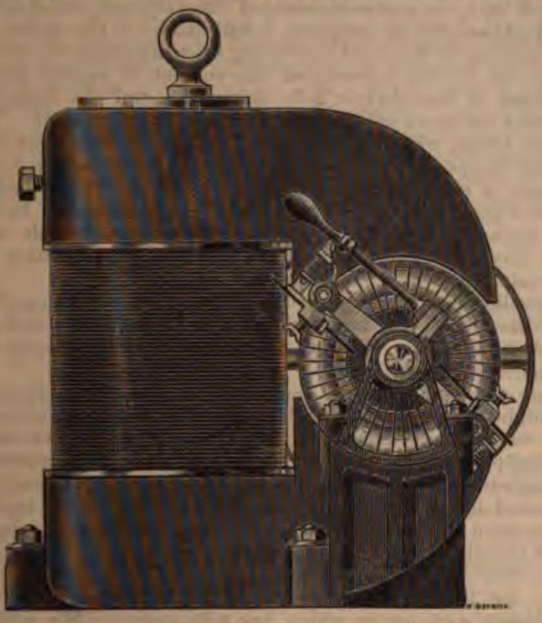


liberated from the positive electrode cannot possibly be contaminated with any hydrogen gas. The gaseous fluorine thus prepared is colourless, and possesses an irritating odour resembling somewhat that of hypochlorous acid. It has very energetic chemical properties, sulphur and selenium both burst into flame when brought into contact with the gas, and tellurium combines with it with incandescence, producing abundant fumes of tellurium fluoride. Phosphorous takes fire in the gas, forming a gas which is absorbed by water (PF_5 or POF_3), and by potash (PF_3). Arsenic, antimony, iodine and crystalised silicon also take fire in the gas, bromine combines with it with explosive violence, but charcoal appears to be unacted upon. The so-called adamantine Boron of Deville is attacked, but with more difficulty than the silicon, but crystaline boron in a state of powder is rendered incandescent, and fumes of boron fluoride are at once produced. The metallic elements are, as a general rule, attacked with much less energy. Potassium and sodium become incandescent, forming the corresponding fluorides, lead is attacked in the cold with formation of lead fluoride, and mercury absorbs the gas completely, forming mercurous fluoride. Gold and platinum are unacted upon in the cold, but when heated to about 300° they are rapidly corroded. The gas liberates iodine from potassium iodide, and lead and mercury iodides are also decomposed with some violence with formation of a fluoride of iodine. Chlorine is liberated in the cold from a fragment of potassium chloride; and phosphorus pentachloride bursts into flame. A crystal of iodoform takes fire in contact with the gas. Dry glass is rapidly etched, water is decomposed in the cold, forming hydrofluoric acid and ozone, and all the organic compounds containing hydrogen which have been examined are violently attacked. M. Moissan has satisfac-

torily proved that the gas liberated at the positive electrode is not a mixture of ozone and hydrofluoric acid vapours, nor is a perfluoride of hydrogen, since the ratio of the volume of hydrofluoric acid to oxygen formed, when the gas decomposes water, is as 4:1, whereas if the gas were a perfluoride of hydrogen we should expect a higher ratio than this. An analysis of the gas was effected by means of bundles of iron-wire, which absorb the fluorine; and, from the increase in weight, the weight of fluorine liberated when a measured volume of hydrogen was collected from the electrode could be ascertained. We see from the above properties of the element that fluorine has chemical activities which are superior to those of all the other known simple bodies. It is interesting to notice that its position as the head of the family of chlorine elements has been thus experimentally confirmed, and its peculiar property of combining with hydrogen in the dark and without the application of heat is noteworthy as the first example of the direct union of two simple gaseous bodies without the intervention of some external source of energy.

RANKIN KENNEDY'S NEW DYNAMOS.

Verily of the making of dynamos there is no end—and this is as it should be—for the dynamo builder, like the architect, must consider the special work his dynamo is intended to perform. The manufacturer, however, has another consideration to take into account, and that is to make a profit. From his point of view too many types are an evil, and thus he aims at designing a few types for



various purposes to meet the largest demands, special machines being constructed at special prices. Mr. Kennedy has introduced one or two new types for construction in the Woodside works. The one known as type B we illustrate herewith. In this dynamo the field magnet is made of three pieces, with only one field bobbin. The core of the bobbin is made of best hammered scrap-iron, and is, in the machine illustrated, 10 inches in diameter and 14 inches long; the other two pieces are of soft cast-iron, and are of much greater cross section than the core of the bobbin. It is claimed that this construction has all the advantages of simplicity of construction, combined with compactness and extremely low magnetic resistance. The armature is built of charcoal iron discs, and the core is turned true, outside and inside, and mounted on metal spokes on a steel shaft; the outsides of the armature are usually turned up true on their shaft, so that perfect balance and truth of centring are obtained. The armature core is 12 inches long, 10 inches in diameter outside, and 6 inches inside diameter, the depth of core being thus 2 inches; the armature is wound with flat wire 5 mm. by 3·5 mm., one layer outside. The current allowed for this armature running constantly for long runs is 90 amperes. The commutator is made of solid-drawn copper sections, insulated with mica. The brushes are adjustable in all directions, and the pressure on the commutator is adjusted by springs. At a speed of about 900 revolutions this machine gives 102 volts at the terminals.

The following is a copy of a careful test by Professor Jamieson, Glasgow, of a 10-unit dynamo of this type, and which is now running continuously from dusk till daylight at Messrs. John Lowson & Son's, Haugh and South-street Works, Forfar:—"I tested this dynamo on Friday, the 4th November, 1887, and had it run continuously for eight hours at full load (with the exception of about half an hour during the workmen's meal hour). The dynamo, which is a self-regulating, compound wound machine, consists of a single horse-shoe magnet, with an armature of the gramme type. The core of the magnet is made of soft, hammered scrap-iron, the pole pieces of hematite cast-iron, and the armature core of soft charcoal iron washers. The whole machine is exceedingly simple, strong, well-proportioned, and well put together. It is just the kind of dynamo for factories, mills, workshops, and steamers, for it may be left in charge of any ordinary mechanic or fireman, with a minimum chance of its getting out of order. All the adjustable parts are readily accessible, and the armature may be removed and replaced in as short a time, and with less trouble, than almost any form of dynamo that I have seen. There is no perceptible sparking at the brushes. The commutator and the brushes, both from their construction and composition, as well as the freedom with which the latter can be adjusted, are calculated to last for a very long time. None of the parts of the dynamo showed any signs of undue heating, and the ventilation of the armature was all that could be desired. From a sample of my electrical tests, it will be observed that the dynamo gave an 'output' of 10,850 watts or 108·5 amperes, and 100 volts at 620 revolutions per minute, and that the electrical efficiency was 89·3 per cent.; which is good for a dynamo expressly designed as a cheap, practical, workshop or factory machine, and not as a special test dynamo for experimental purposes.

"With due attention to the oiling of the bearings, &c., there is no reason why this machine should not work continuously for a week or more on end, without giving the least trouble; and if the future machines made by the same firm are as carefully designed and constructed as the one I had the pleasure of testing, they should give satisfaction to the purchaser. It is a distinct improvement on their former dynamos.

Sample of Electrical Tests.

Resistance of armature, warm	= 0·4 ohm.
Resistance of magnet shunt, warm	= 20 ohms.
Resistance of magnet main coil, warm	= ·03 ohm.
Current in working circuit	= 108·5 amps.
Current in shunt magnet coils	= 5 „
Differ. of potential at dynamo term.	= 100 volts.
Difference of potential at brushes	= 103 „
Speed in revolutions per minute	= 620
Temperature of air	= 60° Fah.
Highest temperature of armature	= 140° Fah.
Highest temperature of magnet coils	= 125° Fah.

Electrical Efficiencies.

External electrical power, or "output" available for electric lighting, &c.—
$= 108{\cdot}5\ \mathrm{A} \times 100\ \mathrm{V} = 10{,}850$ watts $= 89{\cdot}3\%$

Power absorbed by armature—
$= (103{\cdot}5)^2\ \mathrm{A} \times {\cdot}04\omega = 428{\cdot}49$ watts $= 3{\cdot}53\%$

Power absorbed by shunt magnet coils—
$= 5\mathrm{A} \times 103\ \mathrm{V} = 515{\cdot}0$ watts $= 4{\cdot}24\%$

Power absorbed by main magnet coils—
$= (108{\cdot}5)^2\ \mathrm{A} \times {\cdot}03\omega = 353{\cdot}17$ watts $= 2{\cdot}91\%$

Total electrical power— 12,146·66 watts

THE ELECTRIC LIGHTING OF THEATRES.

The following is the translation of a paper communicated by Dr. G. Sous to the Société de Médecine et de Chirurgie de Bordeaux:—

The Greeks and the Romans represented their comedies and their tragedies in daylight, in their public places or in enclosures open to the sky. They have bequeathed to us excellent literary models, but we have not followed their example in the hour chosen for acting our plays. They appropriated the daytime for

their representations, and we have devoted the night to ours, thus placing ourselves under the necessity of illuminating our theatres with artificial light.

Wax, oil, and gas have successively been employed as a source of light, each in its turn being dethroned and superseded; and, in the incessant march of progress, electricity offers itself in our day as a substitute for gas-lighting.

Electricity is the illuminant of to-morrow. It is becoming perfected; it is spreading and growing common. Under many conditions it is called upon to replace gas, without, however, banishing it. It will be to gas what gas has been to oil. Lighting by means of oil has persisted in spite of gas; and gas will continue to fulfil its applications side by side with the electric light.

For some years past, towns, industrial establishments, and theatres have been illuminated by the electric light. Inventors and companies have rivalled each other in zeal to augment their sphere of action; they have seized every occasion to utilise their patents, and have brought into prominence the advantages of the processes they employ. The fire at the Nice theatre, and the more recent one at the Opéra Comique have attracted general attention as to the necessity of a system of lighting which would not expose the public to such disasters, and the electric light has apparently come forward as the only illuminant adapted for theatres.

As Regnauld has well said: "Whenever a physical agent tends to emerge from the exclusive demain of science in order to receive industrial applications, the duty of the scientific medical man is te seek out and anticipate any useful or detrimental consequeuces due to its introduction in domestic economy."

This being the case, confining ourselves exclusively to those optical questions which more particularly interest us, we have to examine what is the electric light, what are its advantages and its inconveniences, and how we should annihilate any of its effects which might be detrimental to the eyesight.

Artificial light is obtained by raising to a high temperature a solid, liquid or gaseous body. In ordinary lighting the elevation of temperature is produced by combustion, the combustion of resin, tallow, wax, oil, essence, or gas. In the electric light the elevation of temperature is due to a current traversing a substance which offers to it a certain resistance.

As in the case of solar light, every artificial light is composed of coloured or luminous rays, calorific rays, and chemical rays. Lights obtained by combustion find in the oxygen of the air the principal source of their activity. They consequently develope a great deal of heat. The heat is the more elevated as the body is gaseous and has the greater affinity for oxygen. The combustion of hydrogen is one of the best-known examples of this law. The electric light not being due to combinations with oxygen, since it can be produced in a vacuum, gives, on the contrary, few calorific rays. In presence of these data, the choice of a light is not a matter of doubt, whether from the point of view of the illumination of theatres or of the precautions to be taken against fire. That system which gives light and but little heat must bear the palm from that which, producing much heat, is also attended with flame which may set fire to adjacent bodies. Gas may become a cause of conflagration, it vitiates the air, it alters the appearance of colours, and in each of these respects it should give way to any system of lighting unaccompanied by the same detrimental effects and leaving to colours their natural tints.

The electric light being produced either by means of the voltaic arc, or by incandescence, we are called upon to establish a distinction, for the effects produced vary materially in these two methods.

Electric Light in General.

The Light from the Voltaic Arc.—Solar light, when decomposed by the prism, produces a spectrum, that is to say, a series of coloured rays, passing from red to violet in the order of their refrangibility. All artificial lights also have a spectrum, containing the same colours as the solar spectrum, and differing from it only by the difference of the extent of each coloured ray.

The best artificial light would be that which in its composition would be most analagous to solar light. In this respect the magnesium light should be placed in the first rank, for it is the one which approximates most to solar light; but it is very costly, and in practice it does not allow of an illumination continued for a lengthened period of time. Thus, magnesium lamps are not found frequently in use; they are mostly employed in the United States by photographers, as it allows of their operating as though in full daylight, either in the night time or in darkened rooms.

The light of gas and that of oil give an excess of yellow rays. In theatres the presence of these rays modifies the tints, whence the necessity of painting the scenery in a particular manner in order to obtain the desired effects, and also the use of rouge in order to give to the face a more natural appearance.

In regard to the electric light, we have to inquire what is its spectral composition, in order to ascertain whether it is detrimental to the eyesight.

In order to simplify the explanation, the coloured rays may be in a measure confounded with the chemical rays, and we may consider the violet and ultra violet rays as being synonymous with the chemical rays, since it is in these violet rays that we find the maximum of chemical rays.

According to most writers, the electric light contains an excess of violet rays; according to a minority there is an abundance of blue and red rays. Again, there are some who have assimilated the electric light to the solar light, and have considered it as a white light.

This divergence of opinion and of observation is not, I think, a matter of feeling. I believe it to be based upon observation, but upon incomplete observation. In fact, from an examination of the spectrum of a given electric light we must not draw a conclusion to be adopted as a general law applicable to all cases. Thus to act would be to commit a serious mistake, for it is necessary to take into account the conditions under which the experiment has been made, since these conditions modify the composition of the light.

The colour of the electric light is affected by three causes—first, the intensity of the current; secondly, the nature of the electrodes; thirdly, the nature of the medium traversed. It is important to know and to make note of these three causes in any experiment, and it is from not having taken them into account that different observers have arrived at diverse results. It is necessary also to take into account the mode of production—voltaic arc, incandescence.

The electric light being produced by an elevation of temperature, the greater the intensity of the current the higher would be the temperature, the resistance to the current being constant, and it is known that the colour of the light is in connection with the temperature. Figures supplied by various writers do not exactly agree, but it is admitted by everybody that the higher the temperature the greater the breadth of the luminous spectrum. Thus, for instance, at 500deg. centigrade we have the red rays, the commencement of the spectrum, and at 800deg. the spectrum will be complete, it will extend to the violet.

The colour of the light depending upon temperature, and this being due to the intensity of the current, it results that the spectrum of the electric light is variable, and the higher the intensity the more will the spectrum become developed. Thus, the arc lamps, which give a greater amount of light than incandescent lamps, have a more complete spectrum. Moreover, in practice, a lengthened examination is not needed in order to detect a great difference between the lights furnished by these two systems. The electrodes exercise also a notable effect. They may be metallic, or with the bases of carbon, either pure or in admixture with various substances.

Metallic electrodes being liable to fusion are seldom employed. They have, however, been utilised, when coated with carbon as a protecting agent. Zinc gives a blue light, silver a green light, and platinum a red light.

Pure carbon gives a pale light, producing a wan appearance; it contains many blue and violet rays. Usually it is in admixture with various substances, which increase its resistance and its lighting power. In order to prevent a too rapid consumption of the carbons and to insulate them, they have sometimes been separated by various substances, which have an effect upon the composition of the light. Kaolin gives a bluish light, plaster a violet tinted light, magnesium a yellow light.

We thus see that the electric light is not of constant composition, not having always an identical spectrum. It varies in accordance with causes which are well known. We need not be surprised that different data have been given by different writers. This follows from the fact that they have not operated under the same conditions.

In what category must we place the electric light produced by the voltaic arc?

In the generality of the apparatus employed, carbon, either alone or in admixture with various substances to augment its luminous power, to render it harder, of greater consistency, and of higher resistance to the current, and also to prevent a too rapid consumption, has been employed. With electrodes having a basis of carbon, the luminous spectrum can only be the spectrum of carbon—that is to say, a spectrum in which the greatest extent is occupied by its rays. The substances which may be added to the carbon will modify the composition of this spectrum—that is to say, will increase or diminish the extent of certain coloured rays such as the red, the yellow, and the blue; but the violet ray will always persist; since the added substances will not do away with the carbon, the spectrum of which will always appear. Thus, the electric light must be considered, in accordance with the statement of most writers, as a light rich in violet and chemical rays.

The nature of the light being known, we are called upon to inquire whether it may be detrimental to the eye by reason of its composition, or whether its action upon the eye is merely the consequence of its luminous intensity.

Before taking up this question, it will be as well to pass in review the main opinions which have been expressed as to the utility of, or the accidents produced by the electric light.

M. de Wecker employed the electric light in Ophtalmology,

and he declares that it agrees with his patients. It should, however, be said that our learned colleague employed a system having a feeble action, a system in which one of the electrodes is of copper and the other of carbon.

According to Mauthner, the electric light is rich in blue and violet rays; but in his opinion this is no drawback. On the contrary, the effect is agreeable to the retina. According to M. Javal there is no detrimental effect. The cases of iritis and conjonctivite which have been indicated in professional electricians are temporary, and due to an abnormal absorption of light. This interpretation instinctively leads us to the hypothesis of fluorescence.

Cohn admits that the electric light irritates the retina from seven to twelve times more than would other flames of equal illuminating power.

"The electric light," says M. Fieuzal, "presents from the hygienic point of view an objection which, I think, has not yet been pointed out: burning in the air, and especially in an almost closed space, it produces hyponitric (? hyponitrous) acid —a gas which in itself is deleterious, and which becomes readily converted into nitric acid by the action of aqueous vapour." To become convinced of the presence of this gas, it is sufficient to smell the atmosphere within one of the more or less opaque globes surrounding the electric light. To give an idea of its effects we may quote the instance of a factory where in a somewhat large workshop, there were fourteen arc lamps. "In winter the windows of the apartment were closed, and after three hours of the lighting the air was no longer respirable, and the workmen were obliged to open the windows."

Luibinsky accuses the electric light of producing temporary myopia due to the contraction of the ciliary muscle—"Recueil d'Ophtalmologie," p. 125, 1881.

Observations on serious accidents produced by the electric light have been published by Nodier, Rockliffe, Emrys John, Little and Fuchs.

M. Bouchardat ended one of his conferences on lighting by these words:—"All that I can say with certainty is that when I happen of an evening to traverse the Avenue de l'Opéra my eyes are strongly affected by this dazzling light and by its continual oscillations, and when I am able I am the first to put in action the tutamina of the eyes and eyelids." According to Stellwag Von Carion, the electric light containing many chemical rays is really very objectionable for the eyesight. Such are the drawbacks which have been indicated; let us see how we may consider them in order to arrive at a means for their avoidance.

(To be continued.)

THE RELATIVE ECONOMY OF THE ALTERNATING AND THE DIRECT CURRENT DYNAMO.

In the paper read by Mr. Wm. Stanley, Jr., before the American Institute of Electrical Engineers, the author draws a comparison between the efficiency of the continuous and alternate current machines, and he finally awards the palm to the alternate current machine. Primarily, however, he shows that the two kinds of machines are equal in economy, by means of the following statements as to the output of each:

Direct current machines: x volts; R ohms; A ampères. Alternating current: $2\,x$ volts; $4\,R$ ohms; $\frac{1}{2}\,A$ ampères. Now, the above statements rest solely upon the assumption that the coils in the alternate current machine are all connected in series, in which case alone the E. M. F. generated would be $2\,x$ volts, as compared with x volts in the direct current machine, in regard to which latter the necessary presumption exists that half the coils are constantly in parallel arc with the other half. For the alternating current generator the average value of the E. M. F. generated would only be $2\,x$ *under like conditions* in the particular case, evidently assumed, that all the armature coils are connected in series. The rest follows as a matter of course, as n coils connected in parallel arc with n similar coils offer one-quarter the resistance of n coils connected to n similar coils in series. The resultant deductions would be true only upon the assumption of like conditions for both.

These conditions, however, do not exist in practice, and regarded simply as mathematics, the statements are also open to criticism. It is evident that so far as the work performed in generating E. M. F., that is, the rate of cutting lines of force, is concerned, the average result is identical for the two types of machine, as the mere adaptation of a commutator for the rectification of reversed currents has no effect upon the resultant values. But the E. M. F., and consequently the current generated in the alternating machine, is the direct result of two factors, namely, the rate of cutting lines of force and the self induction of the circuit, which last may be neglected without sensible error in the calculations for the average electromotive force in the direct current machine. But it cannot be neglected in the alternating current machine as at present constructed. The effects of self induction react at each change of field upon the moving coil, and the resultant effect is a subtractive quantity which must be deducted from the average amount of electromotive force generated. Any conclusions based upon a neglect of this important factor cannot be mathematically correct. Were there no self induction in the armature circuit, the expression for the average electromotive force E in both machines would be:

$E = 4\,n\,A\,H.$ In which

n = number of revolutions or turns in unit of time.

A = equivalent area of armature coil.

H = number of lines of force per unit area of field.

The above is the average value of the integral of

$$-\frac{d\,n}{d\,t} = E.$$

For alternate current machines a subtractive term enters, which depends upon the self induction of the circuit.

For the latter machine we have:

$$E = -\frac{d\,n}{d\,t} = -\frac{d\,(A\,H\cos\theta + L\,i)}{d\,t};$$

which reduces to $E = \frac{2\,\pi\,A\,H}{T}\,\sin\,\frac{2\,\pi\,t}{T} - L\frac{d\,i}{d\,t};$

in which is introduced a subtraction term which depends upon the self induction of the circuit, and is a function of the current flowing, i. Neglecting this term, the value of E reduces to:

$$E = 2\,\pi\,n\,A\,H\sin\theta,$$

for which the average value is $4\,n\,A\,H$ as before.

As regards the Westinghouse machine, a further error is introduced in the assumption that the coils are all in series. Illustrations of the machine all show them connected in single multiple arc, which, so far as the equations for the E. M. F. are concerned, would simply have the effect of reducing any such machine to the form of one having half the number of fields.—*Electrical World.*

EFFICIENCY AND REGULATION OF ELECTRIC SYSTEMS.

Dr. Louis Duncan, writing to the *Electrical World*, points out that, industrially, the question of electric lighting has now entered well upon a new phase. The question is no longer Is it possible? but, Can it be rendered economical? The consideration of losses is therefore most important. Dr. Duncan thus classifies the principal losses in a dynamo:—

1. Friction; including friction of bearings and brushes, and resistance of air. 2. Eddy currents. 3. Loss in that coil of the armature which is short-circuited by the brushes. 4. Loss due to reversal of magnetism in the armature. 5. Induced currents in the pole pieces. 6. Energy of sparks 7. Loss in fild magnet coils. 8. Loss in armature coils. These losses manifest themselves as heat.

He first considers a shunt-wound, constant potential dynamo, and the variations of these items as the load varies.

As the speed of the machine is constant, and the potential at the terminals is constant, the magnetic field is almost constant; it must be slightly stronger as the load increases, for the total E.M.F. must be a little greater as the current is greater; but for our purposes we may consider it constant. The speed being constant, then, if Morin's law holds for the sum of the tensions on the two sides of the belt, we have one constant for the friction.

The E.M.F. in the eddy circuit depends on the same factors that the E.M.F. of the dynamo does, and as the resistance of these circuits is constant, this loss also is constant.

The loss in the coil short-circuited by the brushes depends upon its resistance and self-induction, and upon the strength and relative direction of the field. It is also affected by the current in the armature, but not to any considerable extent. These factors being constant, this loss will be constant. The loss due to the reversal of magnetism in the armature depends upon the strength of the field and the velocity of the rotation, and is therefore constant. The induced currents in the pole pieces of of the ordinary shunt-dynamo can be neglected. The loss would depend on the fluctuations in the current, which

would be slight. The loss by sparkling should be inappreciable in well-constructed machines which are not overloaded. Up to a certain load, beyond which the machine should not be run, it will be very small, varying with the adjustment. The loss in the magnet coils is nearly constant, increasing slightly with the load. The loss in the armature coils varies as C^2. We may consider, then, that the losses in a constant potential dynamo are constant, excepting only the loss due to the heating of the armature coils by the current, or we may represent the loss in horse-power as :—

$$A + \frac{C^2 R}{746}$$

We should be able then from the measured efficiency at any load to deduce the approximate efficiency for any other load; providing the current in the armature is not strong enough to seriously reduce the strength of the field and cause sparking.

Experiments of the Franklin Institute are considered as follows:—In these the armature friction was slight since the armatures were coupled directly to the dynamometer shaft, and there was no belt to pull them up against the bearings. Indeed, it is interesting and instructive to compare the friction of the armature under these circumstances with that of the pulley of the dynamometer. The latter weighed several hundred lbs., and was tightly belted. The armature friction varied from ·16 h. p. to ·4 h. p. in dynamos whose armatures varied in weight from three or four to perhaps 1,500lbs., while the friction of the pulley and the work absorbed in bending the belt was considerably over a horse-power, varying with the tension of the belt and the speed.

The figures given are from tests of two different types of dynamos. The last loads given are considerably in excess of the normal output. The results are reduced to the value of the ohm = 106·25cm. of mercury.

EDISON NO. 4 DYNAMO.

Power applied in h.-p.	4·2	7·3	12·5	14	18
Losses except $C^2 R$	1·16	1·21	1·26	1·22	1·39

WESTON 6M. DYNAMO.

Power applied	4	7	11	13	14·4
Losses except $C^2 R$	·77	·73	·73	·91	1·04

In the last column of the Edison and the last two columns of the Weston machine the load was greater than that normally used, and the effect of the armature current increased the loss in the field and in sparking to a considerable extent. Within the limit of ordinary use, however, the losses on different loads may be regarded as approximately constant. The efficiency may then be expressed in terms of the power applied or

$$Ef. = 1 - \frac{A + C^2 R}{\text{work.}}$$

The losses in constant current dynamos vary with the method of regulation. A large number of dynamos in commercial use are regulated by shifting the brushes in such a way as to make the potential at the terminals vary with the resistance in the external circuit. Consider this case, supposing the machine series wound. The current around the field magnets remains constant, and we should have a constant strength of field but for the reaction of the armature. This will vary with the lead of the brushes, but in well constructed machines it should not be great. Our losses, then, should be constant, with the exception of that due to sparkling and to the loss in the short circuited coil, supposing the dynamo is a closed circuit machine. Both of these last would increase as the displacement of the brushes increases, or would be greater as the load is less. As the other losses would slightly decrease it may be assumed that the loss, taking everything together, would be nearly constant; or for our purpose we can put

$$Ef. = 1 - \frac{A}{\text{work.}}$$

For the classes of machines considered, then, the efficiency will be low for small loads and will increase until effects given under 5, 6, 7, and 8 become prominent, when it will decrease again.

CENTRAL STATION LIGHTING AT LUBECK.

In February, 1884, the German Edison Company asked the Senate for a licence and concession for the supply of electric light for Lübeck. This request was not granted, as the town intended to do the work itself. A committee was elected for the thorough investigation of the matter, and on the 19th July, 1886, the Senate and Council decided, after hearing the report of the committee, upon erecting an electric plant under the auspices of the State of Lubeck. Tenders for executing the work were solicited, and M. Schuckert, of Nuremberg, was given the contract in February, 1887, for the whole plant—dynamos, apparatus, instruments, and cables, and including the connections with the installations of private buildings. It was only after Easter, however, that the contractor could commence with the building of engine and boiler houses. The erection of these buildings, together with the placing of the boiler, the steam engines and dynamos, and the laying of the cables and installations, took a much longer time than was at first anticipated, and the month of August came before the contractor could proceed with the erection of the steam engines, dynamos, and the electric apparatus. Simultaneously with the completion of the whole of the works in the engine-house, the cable last put underground was tested. After sundry trials in the engine-house and in a small number of private buildings had been made in the beginning of the month, on the 16th of November the whole system was shown in operation, including about 1,000 glow lamps (16-candle power) and about twenty arc lamps of 600-candle power, to which exhibition the members of the Senate and Town Council were invited. The first trial, as well as subsequent ones, proved to be a great success, and the plant has shown itself to be well executed in all its details. The whole system was started working on November 22nd, 1887, and has earned the fullest commendation not only from the knowing ones, but from the general public. Originally the plant was only intended for a regular supply for 3,000 glow lamps (10-candle power) and 100 arc lamps (400-candle power), requiring 250-horse power. However, when laying down the plant it was thought better to have a respectable reserve, and also to make provision for the extension of the system by one-half. The underground cables were at the same time prepared so as to give sufficient conducting power for the calculated increase.

The engine-house and chimney are erected in the centre of the town. The engine-house is closely connected with the boiler-house. Nearest to the entrance is a single-cylinder steam engine, of about 50-horse power, with a wrought-iron flywheel of three metres diameter. Behind are placed four dynamos of the well-known Schuckert construction. Each dynamo gives an electric current capable of supplying electricity for 700 16-candle power glow lamps. Two more dynamos of the same capacity will be fixed when the installation is extended, the foundations for which extensions have already been laid. For driving the four dynamos already fixed two large compound steam engines of 200-horse power each have been obtained, and each of them is furnished with a flywheel of 3¾ metres diameter. Both engines are fitted with storage and condensing apparatus. Along one side of the engine-house is placed the common driving shaft, which is driven by the engines by means of flax ropes, the dynamos being driven from the shaft by means of leather belts. The transmitting shaft is supplied with frictional clutches and pulleys, by means of which both the steam engines, as well as the dynamos, can be adjusted at will while the machinery is in motion. Close to the engine-house, and separated from it by a wall, is the boiler-house, in which are three of Heine's patent water-pipe boilers, manufactured by Borsig, of Berlin. Each boiler has a heating area of 70 square metres. These boilers are in connection with a chimney 40 metres high. On the other side of the engine-house, at the same height as the dynamos, is placed a most interesting apparatus provided with controllers and regulators. From the dynamos are cables bedded under the floor leading to the switch-board, and from thence beyond they lead to two strong copper rails which take the entire current from the dynamos. With the aid of the switch-board the current from any of the dynamos can, while the engines are in motion, be excluded or otherwise, without influencing in the least the current-creating power of the remaining dynamos. Am and volt meters are used to indicate current and pressure. The pressure, in spite of the occasional occurrence of irregularity in the motion of the engines is, in a most simple manner, kept at an exactly normal through resistance. The arrangement is such that two dynamos in work can be equally worked, or one may generate the whole current whilst the other remains motionless. Nine pairs of cables branch from the above-mentioned copper rails which directly lead the current to the division centres. Each pair of cables is provided with a current meter, which indicates the current upon it at any time, and also with a regulator, which automatically regulates the current and keeps it at the pressure required by the consumer. By this means a double object is arrived at. Firstly, the lamps get the required current and the necessary light, whilst the plant is secured from waste through efficient regulation. The row of controlling lamps, while serving to light the premises where the light is produced, also show the quality and efficiency of the lights throughout the entire installation. By means of two volt meters, at any time it can be ascertained whether the pressure is too high or otherwise. There are nine couples of principal cables, already referred to, which lead the current from the engine-house to the so-called diviision centres; and branch cables which lead from the division centres through the streets and supply the electricity throughout the town. Altogether there are about 10,000 metres of lighting cables laid through the principal streets, the diameter of which measure, according to the strength of the current, from 40 to 240 square metres. The city of Lubeck is the first in Germany to decide upon constructing an electric central station at its own expense

and under its own municipal supervision, and that this step is being recognised as one worthy of imitation may be learnt from the fact that already, it is said, a great number of towns intend to follow its example.

PORTABLE VOLTMETERS FOR MEASURING ALTERNATING POTENTIAL DIFFERENCES.

BY PROFESSORS W. E. AYRTON AND JOHN PERRY.

(Continued from page 23.)

This result was obtained experimentally by Professor Forbes in 1884,* but he appeared to regard it as a result that would not have been expected from experiments previously made on much thicker wires. Mr. Preece also published results,† in the same year, of experiments made on fine wires, and he also speaks of the results of experiments "contradicting" the law which he obtains theoretically. Whereas it appears to us that the current having to vary directly as the diameter, and not as the diameter raised to the power three halves, in order that *very fine* wires may be maintained at the same temperature, is in entire conformity with the true law of the loss of heat by radiation and convection, which was published certainly as early as twenty years ago by Mr. Box.

Equation (5) becomes

$$\theta = \frac{V^2 d}{4 l_0^2 \epsilon \rho_0 (1 + k\theta)},$$

or

$$\theta = \frac{V^2 d}{4 l_0^2 \epsilon \rho_0 \left(1 + k \frac{V^2 d}{4 l_0^2 \epsilon \rho_0}\right)}, \text{ approximately} \quad (5)$$

One law of the magnifying spring is that

$$\phi = \frac{s}{r}(y - y_0) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (6)$$

where ϕ is the rotation of the pointer in radians, s is a number depending upon the material of which the spring is made, and has a value about 1 radian for phosphor bronze, and r is the radius of the spring.‡

Substituting for y from (6) in (2), we have, as

$$y = \frac{r\phi}{s} + y_0,$$

$$\frac{r^2}{s^2}\phi^2 + 2\frac{r}{s} y_0 \phi = \tfrac{1}{2} l_0^2 a \frac{V^2 d}{4 l_0^2 \epsilon \rho_0 \left(1 + k \frac{V^2 d}{4 l_0^2 \epsilon \rho_0}\right)},$$

or

$$\phi^2 + 2\frac{s}{r} y_0 \phi = \frac{s^2}{r^2}\frac{d a}{8 \epsilon \rho_0}\frac{V^2}{1 + \frac{k d}{4 l^2 \epsilon \rho_0} V^2} \quad . \; . \; . \; . \quad (7)$$

or if

$$A = \frac{s^2}{r^2}\frac{d a}{8 \epsilon \rho_0}, \text{ and } B = \frac{k d}{4 l_0^2 \epsilon \rho_0},$$

and if $\frac{s}{r} y_0$ be called ϕ_0, then

$$\phi^2 + 2\phi_0 \phi = \frac{A V^2}{1 + B V^2} \quad . \; . \; . \; . \; . \; . \quad (8)$$

and hence

$$\phi = \phi_0 \left\{ -1 + \sqrt{1 + \frac{A}{\phi_0^2}\frac{V^2}{1 + B V^2}} \right\} \quad . \; . \; . \quad (9)$$

There are discrepancies in this result, due to—

1st. Our assuming (1). But it will be found that the error due to this assumption is not large for the usual temperatures of the instrument when platinum-silver wire is employed, see F—"Correction for Temperature."

2nd. Our assuming ϵ to be independent of θ. If ϵ is not constant, the law (9) alters in shape. As we never use (9) for the purpose of graduating, but merely to give us some approximate knowledge of a general law, this will not affect in any way the accuracy of the instrument.

3rd. We have not taken into account the fact that time is needed to attain the state of equilibrium indicated by (4), so that θ might be expected to rise higher on first starting the current than its true steady value; but we find experimentally that this time is quite inappreciable with a *very fine* wire placed *horizontally*.

4th. Our having neglected small changes in y due to the tensile strain in the wire. It can be proved that these are unimportant, except when y_0 is smaller than we are ever able to have it in our instruments.

5th. Our having dealt with certain small quantities as if they were indefinitely small.

B is found to be very small in our instruments, and when y_0 is very small it is obvious that the deflection ϕ of the pointer is very nearly proportional to V, the potential difference. When y_0 is not small, the readings increase at first in proportion to the square of the volts, and then become more nearly proportional to the volts. In fact, the divisions for volts of the scale of the instrument get rapidly greater for small readings; then, as the readings become higher, the divisions become equal to one another; and if the range is high enough they become somewhat smaller again, due to the change of resistance with temperature making its effects felt.

For the sake of illustration we have drawn the three curves shown in Fig. 11, taking

$$A = \cdot 01$$

and

$$B = \cdot 0001,$$

and the values 0, 1, and 2 for ϕ_0.

If such a spring is used that $\frac{s}{r} = 1$, then ϕ_0 is y_0.

B.—Waste of Power in the Voltmeter.

From the equations previously given it follows that the waste of power in watts spent in keeping a long fine wire l_0 centimetres in length $\theta°$ C. above the temperature of the surrounding space equals

$$0{\cdot}0008848\, \pi\, l_0\, \theta,$$

a value which depends only on the length of the wire and on the temperature to which it is raised above the temperature of the case, but not at all on the diameter of the wire. This result is confirmed by the experiments recently made by Mr. Evershed, who has found that about 36 watts are required to keep a wire 3,600 mms. long at a temperature of about 180° C. above the temperature of the case, whether the wire be 0·038 mm. or 0·0635 mm. or 0·0889 mm. (*i.e.*, 1·5 or 2·5 or 3.5 mills.) in diameter. Substituting 360 centimetres for l_0 in the above expression, and 180° C. for θ, the value becomes 180·2 watts. This is more than four times the value obtained by Mr. Evershed, and the reason may be partly due to the fact that (as already noticed in section A) we have hitherto regarded the rate of loss of heat as being directly proportional to the difference of temperature. On turning to Mr. McFarlane's paper we find his result may be expressed as follows:—

Loss of heat per second per square centimetre of a bright copper ball 2 centimetres in radius for a difference of temperature $\theta°$ C.

$$= \text{Loss for } 1° \text{ C.} \times \theta\left(\frac{0{\cdot}000168}{0{\cdot}000170} + \frac{1{\cdot}98}{\cdot 000170} \times 10^{-6}\theta - \frac{1{\cdot}7}{\cdot 000170} \times 10^{-8}\theta^2\right).$$

Instead, therefore, of writing as above the expression for the rate of loss of heat in watts required to maintain a long wire l_0 centimetres in length of a temperature $\theta°$ C. above that of the surrounding space, it will probably be more correct to write it as something like.

$$0{\cdot}0008848\pi l_0 \theta \left(\frac{0{\cdot}000168}{0{\cdot}000170} + \frac{1{\cdot}98}{\cdot 000170} \times 10^{-6}\theta - \frac{1{\cdot}7}{\cdot 000170} \times 10^{-8}\theta^2\right).$$

If now we substitute 360 centimetres for l_0 in this expression, it becomes

$$\theta\,(0{\cdot}9883 + 0{\cdot}01165\,\theta - 10^{-4}\,\theta^2) \text{ watts.}$$

Of course we cannot expect this expression to give absolutely correct results for any values of θ, seeing that Mr. McFarlane's experiments did not extend beyond θ equal 60° C. The expression is interesting, however, as showing that, in consequence of the negative term, ϵ must be taken as having a smaller value when θ is high than when θ is low. For θ equal to 180° C., which was about the excess temperature of the wire in Mr. Evershed's experiments, the formula as it stands cannot be applied, as it leads to a negative answer; but for θ equal to 164·5° C. it gives, as it happens, almost exactly 36 watts, the power Mr. Evershed found was expended in any one of the three wires he tried.

Mr. Evershed informs us that he estimates the temperature to which the wire is raised by measuring its expansion; we, on the other hand, have found it more convenient, with our form of voltmeter, to estimate the rise of temperature of the wire by measuring its increase of resistance. Employing this latter method, we find that, roughly, 3·5 watts per foot are necessary to maintain a very fine platinum-silver wire at a temperature of 200° C. above that of the case. This result is rather higher than that obtained by Mr. Evershed, and corresponds with a value of ϵ equal to about $\frac{0{\cdot}0002}{d}$.

* *Jour. Soc. Tel. Eng.*, Vol. xiii., 1884, page 243.
† *Proc. Roy. Soc.*, No. 231, page 468.
‡ "A New Form of Spring for Electric and other Measuring Instruments," *Proc. Roy. Soc.*, No. 230, 1884, page 306.

In the absence of the results of experiments made for many values of θ it is impossible to say what is the exact function of θ that ought to be employed in the expression for the watts; and consequently we are at present engaged on experiments for determining this function. From what we have given, however, there is reason to think that the expression for the watts required to be spent in maintaining a long fine wire at any temperature θ above that of the surrounding space is a function of the length of the wire and the excess temperature only, and is nearly, if not entirely, independent of the diameter of the wire.

C.—The Range in Volts.

If θ_1 be the highest temperature of the wire allowable; if V_1 volts be the range of the instrument without using external resistance coils, then, from (4),

$$V_1 = 2\, l_0 \sqrt{\frac{\epsilon\, \rho\, \theta_1}{d}} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

so that this range is proportional to l_0—that is, to the length of wire through which the current passes in going from one terminal to another of the instrument. Hence, if there are 10 wires, each of length λ_0, we can make $l_0 = 10\,\lambda_0$ by placing the wires in series, or $l_0 = \lambda_0$ by placing them in parallel by means of a commutator.

Since, for small wires, ϵ is inversely as d, the range in volts increases directly as the length of the stretched wire and inversely as its diameter. As, however, increasing the length increases the waste of power in the instrument, it is rather by diminishing the diameter of the wire that the range in volts ought to be increased.

If a small range in volts be desired, it is better, in order to avoid waste of power, to use one thick wire than several thin wires in parallel; and this rule ought to be followed as long as the thick wire is sufficiently quick in its action.

In order, however, to obtain a great range, it may in many cases be desirable to employ a many-wire voltmeter with a commutator, in spite of the fact that this arrangement does not give the instrument that is most economical in the power wasted when a few volts are being measured.

D.—The Greatest Angular Deflection of the Pointer.

With any given spring, it is obvious that we ought to tighten the wire and adjust the initial tension in the spring until the initial pull in the wire is q—the greatest pull to which the wire ought to be subjected—and also until we find that at the highest temperature the spring is just able to keep the wire taut. In our instruments where the wires lie nearly all parallel to one another we have these two adjustments, and also in those with the bicycle-wheel arrangement of wires, in which the outer ends of the wires may be attached to adjustable flexible strips. For the sake of easy calculation we may take the final pull in the spring as 0. Let L be the length of the spring, ϕ_1 the deflection of the pointer when θ_1 (the highest temperature of the wire) is reached, P_0 the initial pull in the spring. By the triangle of forces

$$P_0 = \frac{4\, y_0 = q}{l_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

(If there are n wires caught by the end of the spring, say n complete diametral wires in the bicycle-wheel form, then instead of q we must use $n\,q$.)

The law of the spring is such that

$$y_1 - y_0 = r\, P_0\, L \frac{a}{t^3} \quad . \quad . \quad . \quad . \quad . \quad (12)^*$$

where r is the radius of the coils of the spring, L its axial length, a a constant depending on the material of the spring, t the thickness of the strip of which the spring is made; and another law of the spring is

$$\phi_1 = P_0\, L \frac{b}{t^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where b is a constant like a. In fact, $\frac{b}{a}$ is the constant s used in (6).

Substituting for P_0 from (11) in (12),

$$y_1 - y_0 = r\, L \frac{a}{t^3}\, \frac{4\, q}{l_0} y_0 = S \frac{r}{t^3} y_0, \text{ say} \quad . \quad . \quad . \quad (14)$$

equation (2) is

$$y_1^2 - y_0^2 = \tfrac{1}{2}\, l_0^2\, a\, \theta_1 = R, \text{ say.}$$

Dividing by (14) we have

$$y_1 + y_0 = \frac{R\, t^3}{S\, r\, y_0};$$

so that

$$y_1 = \frac{R\, t^3}{S\, r\, y_0} - y_0.$$

Substituting in (14), we find

$$\frac{R\, t^3}{S\, r\, y_0} - 2\, y_0 = S \frac{r}{t^3} y_0,$$

or

$$y_0 = \sqrt{\frac{R}{S \frac{r}{t^3}\left(S \frac{r}{t^3} + 2\right)}} \quad . \quad . \quad . \quad . \quad (14)$$

Substituting for P_0 from (11) in (13),

$$\phi_1 = \frac{L\, b}{t_3}\, \frac{4\, q}{l_0} y_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

and using y_0, just found, in which $R = 2\, l_0^2\, a\, \theta_1$, and $S = \frac{4\, L\, a\, q}{l_0}$, we find eventually that

$$\phi_1 = \sqrt{a\, \theta_1\, \frac{b^2}{a}\, \frac{L\, q\, l_0^2}{2\, L\, a\, q\, r^2 + r\, t^3\, l_0}} \quad . \quad . \quad (16)$$

where neither of the two terms in the denominator is negligible. The observation in brackets given after (11) tells us that we may use $n q$ instead of q in the formula if there are n lengths of wire or n complete diametral wires in the bicycle-wheel form of instrument. An examination of (16) will show how the range ϕ_1 may be made large.

The following are the deductions that may be drawn from (16):—

1st. If f be the working stress suitable for the material of the wire,

$$q = f \frac{\pi}{4} d^2,$$

or

$$n\, q = n\, f \frac{\pi}{4} d^2;$$

so that, if we desire a large maximum deflection without reference to the range of volts, we ought to use wires as thick as possible, or else use many spokes in the bicycle-wheel form. The limit to the thickness that may be given to the wires arises from the fact that the heat equilibrum will only be established slowly with thick wires, so that the dead-beat character of the instrument suffers if the wires be too thick.

2nd. The greater l_0 is, the greater is the maximum deflection. Hence the greater the diameter of the bicycle wheel and the more numerous the spokes, the greater the maximum deflection. Also, the greater the diameter of the bicycle wheel and the greater the number of spokes, still more noticeable is the range in volts.

3rd. Diminishing the thickness (t) of the strip of metal of which the spring is made has a *very great* effect in increasing the maximum deflection.

4th. Increasing the length (L) of the spring increases the maximum deflection just in the same way as increasing q or $n\,q$.

5th. Diminishing r, the radius of the coils of the spring, produces a great increase in the maximum deflection.

(To be continued).

* "A New Form of Spring for Electric and other Measuring Instruments," *Proceedings* Royal Society, No. 230, 1884, page 311.

INSTITUTION OF ELECTRICAL ENGINEERS.

The first meeting of this session was held in the theatre of the Institution of Civil Engineers, Great George-street, on Thursday last, when Sir C. Bright vacated the Presidential Chair, and introduced his successor, Mr. E. Graves, who proceeded to deliver his inaugural address, as follows:—

According to the poetic mythology of ancient Greece, Minerva, fully grown and armed, sprang from the brain of Jove: Wisdom was perfect at its birth; neither study, observation, nor experience were necessary to bring it to maturity.

But the wisdom of the early civilisations dealt only with the external aspect of material things. The hidden secrets of Nature were undisturbed. The philosophers of those days forebore to look below the surface, nor did they call into activity forces dormant until the moment that the researches of the investigator should stir them into life.

When that period arrived it was manifested by progress in a very different manner from the sudden growth symbolised by the myth of Minerva. First, the observance of strange phenomena, and of the fact that their reproduction, under similar or differing conditions, as the case might be, was possible. Next, the discovery of distinct purposes that could be effected, by the utilisation of the same force that had given rise to the phenomenon originally observed. Then, the knowledge of the means by which this force could be produced, to whatever extent it might be required or be capable of, and that when produced it could be controlled; and lastly, the combination, into a definite scheme, of the results of all these researches and discoveries, so that the principles regulating the new science might be formulated, and its leading laws made known—thus creating a basis upon which could be ultimately moulded a more or less valuable addition to the resources of the human race.

The various stages through which the growth of any original science must necessarily pass can be stated in a brief paragraph, but to realise them centuries are often required.

Electricity and magnetism, which may be regarded for our present purpose as varying expressions of the one original power, furnish a clear illustration of this fact. Even now our knowledge, both of the agent itself and of the possible uses to which it may be applied, is very incomplete; but being what it is we can clearly trace its evolution.

Neglecting the earlier observers, who merely noted the existence of startling facts which they neither endeavoured to reason upon nor explain, we may fairly say that from Gilbert, of Colchester, to Faraday, three complete centuries were occupied in nearly continuous investigation of the laws that govern the action of the mysterious agency, and of the methods by which its powers could be controlled and employed. A long list of names of distinguished men in all civilised countries shows that many minds co-operated in the enquiry, and aided to piece together, observation by observation and discovery by discovery, that mighty outcome of scientific origin, which, in many respects, has revolutionised the material world, and will still further—how much further one dares not say—influence its destiny.

Faraday and Joule may be regarded as the last workers and discoverers—of English birth at least—in the field we are considering, who trod its path with absolute devotion to pure science alone. They and their predecessors noted facts and deduced principles; they stored up a mass of observations for the guidance of their successors, but they did not seek to apply them so as to turn the knowledge that had been gained to commercial account.

A different state of things now exists. Long prior to Faraday's decease, other earnest students of electric science saw that, in realising the triumphs that it might attain, benefit might be secured to their race and to themselves alike. The hour had come when the labourer could reap the reward of his efforts, and profit by the devotion of his life to the study of Nature's laws. Since then every distinguished electrician has applied the science he loves to some practical purpose. When success has been secured in one department it serves only as a spur to further exertions, seeing that success means reward, and thus the recurring stimulus produces greater and greater efforts, and wider and more far-reaching results.

The object of the compiler of this address has been, however imperfectly, to trace the nature of the benefits already conferred upon the world by the use of electricity in some of its varied expressions, and to gauge the extent of the employment it has given, by means of its operations, to at least the inhabitants of our own country.

It is almost impossible to express the variety of ways in which the action of electricity is utilised. Their name is legion, and they are ever multiplying. Communication between distant places was the first widely extended purpose to which it was practically put. Originally its operations were confined to points separated by land only. Then intervening rivers, channels, seas, and oceans were successively crossed, until now nearly the whole earth is bound together by submerged chains—a kindly bondage that is another name for union. One ocean only—the Pacific—remains uncrossed, and the barren distinction will hardly be much longer preserved. One country of importance only—the Empire of China—has hitherto been reluctant to encourage the lightning messenger, but that reluctance appears to be on the verge of disappearing.

Another most prominent utilisation of electricity is for the purpose of illumination. First practically discovered by Humphrey Davy, its powers in this direction were successively made practical by Wylde and De Meritens, Pacinotti and Gramme, and by many eminent scientists of later date. Electric lighting has passed very many stages. Differing from telegraphy, it needed a longer period of trial and experiment after its commercial application began; and it is, of course, exposed to the competition of other illuminants ever seeking, by new methods, to lessen its superiority. Economy of production is, perhaps, the great necessity for its complete development. As the light of brilliance, health, and beauty, its claims are universally acknowledged; but the commercial problem can hardly be said to be yet completely solved, although the steps taken in that direction give promise of a satisfactory solution being not far off: the problem of distribution is becoming understood.

Telephony—in other words, telegraphing by means of the sonorous vibrations of the human voice, and not by means of signals controlled by the human hand—came into the field comparatively recently, but has met with wide acceptance and has had a vigorous growth. It has been welcomed in all countries as a boon to humanity. The delicacy of the instruments by which it is worked is, perhaps, the source of greatest difficulty that its further development has to overcome: their sensitiveness is alike manifested to intended and unwished-for influences. Since their inception we have had means of observation far more delicate than any previously in general use, but we have also discovered that the influence of "induction" is apparent to a much greater degree than was before deemed probable as an interference with the practical working of electric communication for commercial purposes.

In electro-metallurgy, electro-plating, electro-typing, and the like uses, electricity operates in many different directions. In some branches it is employed as a new and better way of producing the same results that were previously produced by inferior means; in some the results attained are novel, as well as the methods employed.

The substitution of electricity for steam, water, or gas, as a source of power, capable of driving mechanical engines, either stationary, locomotive, or marine, and the transmission of similar power to a distance from its source of origin, although successfully carried out in many important instances, may be considered as yet rather in the earlier stages of experiment and growth than of those of completion. There is a wide field yet to be explored in this direction.

For medical purposes electricity is also extensively employed; but I confess that I am unable to separate the wheat *from the tares*—the really curative agent from the imposture—and therefore can only say it is evident that much may be done in this direction; much is already done, but the extent of the area it will finally occupy cannot yet be perceived. When the real nature of the power employed is understood, then we can better appreciate the nature of its influence upon the ailments to which the human frame is subject.

As a warning against fires that may threaten our houses, an agent employed to summon helpers to our relief, the electric current renders great service, that will, it is to be hoped, be availed of more extensively in the future than it is at present.

Electricity is also utilised to an increasing extent as a safeguard to the lives of the toilers in our coal mines charged with explosive gases. As yet it is somewhat of an uncertain stage in this respect—its use is proved, the desirability of its employment recognised, and efficient instruments for the purpose devised, but practice is yet needed to remove the difficulties in the way of its general adoption, to overcome the inertia that blocks its path.

Like the steam hammer that can strike with the weight of many tons, or crack a nutshell with a gentle tap, electricity can unite sundered continents or serve as a household convenience. For ringing the bells of our houses it has practically superseded the apparatus of pulleys, cranks, and movable wires; it can be operated over distances to which they were inapplicable. For submarine mining, blasting rocks, firing discharges that cause mountains to crumble, and for the purposes of warfare, the heat-conveying powers of electricity are extensively employed.

The last of the uses of electricity that I will particularise was one of the earliest to be availed of: a species of telegraphing with a special object, guiding trains on their way, and guarding against the risk of collisions by night and by day. When steam had won its greatest victories, it was necessary that some swifter and more subtle power should be at hand to control and regulate its action. Such power was found in the use of electricity, by means of which signals are given that track and guide the moving train throughout its journey. The line of railway is divided into successive sections, into each of which a train is forbidden to enter until the electric indicator gives permission, such permission being withheld until it is announced, by similar means, that any preceding train has passed from the further end of the section, upon which its successor is allowed to enter.

I have so far specified a few of the leading purposes for which electricity is employed, but to enumerate them all is practically impossible; the sphere of its influence is widening every day, and no one can attempt to say when its ultimate limits will be reached.

Only on Saturday last I saw an announcement in an evening journal to the effect that it had been discovered that the passage of a powerful stream of electricity through sewage water effected the division of the solid from the liquid constituents of the latter. No practical description of the *modus operandi* was given; but the bare announcement, whatever the results, shows a new direction in which some minds, at least, hope that profitable employment for the electric agent may be found.

It is clear, however, that in the great majority of its applications electricity is used as an agent—a tool, so to speak—for producing effects hitherto obtained less perfectly and less extensively by other means. For illumination, the supply of power, for plating, and many other purposes to the production of which electricity is applied, means existed in one form or other before the use or value of the latter was known. The improvement, however, effected by its use in some processes has been so great that it amounts almost to a discovery, and in almost all there is still great scope for increased progress.

One of these processes may be mentioned in the case of the electric light as applied to the illumination of ships—notably in passenger steamers—at sea. The contrast between the comparatively dim oil lamps and the bright glow of the incandescent lights is so great as to make the latter really a new thing. Gas cannot, for self-evident reasons, be commercially applied to our floating palaces. Electricity has therein found a field in which it has no competitor.

Telegraphy and telephony, however, have introduced a really new thing into the world. True, the word "telegraph" was applied to an instrument—the semaphore, which preceded that which we mean when we use the same expression; but its operations were so limited—darkness or fog suspending them entirely—that no real comparison between the apparatus of Wheatstone and Morse and their so-called mechanical predecessor can be instituted. A few lines of gaunt-looking frameworks, on which hung pendant legs and arms of wood, or closing and opening shutters worked by levers, stood at considerable distances from each other. The signals expressed by the persons controlling the first machine in any such line were noted by an observer stationed at the next machine through a powerful telescope; from the second they were repeated to the third; and so, when the light and weather permitted, they reached the final point communicated with, sometimes with very considerable rapidity. Nearly all such lines—and they were not many in England—were entirely for the Government service, chiefly that of the Admiralty. The only long private line of communication of the kind of which I am aware was that belonging to the Mersey Docks and Harbour Board—from Birkenhead to Holyhead—used for signalling the arrival or departure of vessels. Imperfect as such means of communication, often interrupted, were, when their operations *did* succeed they were enough to show how great the advantage would be to the world in general if they could be permanently depended upon. Hence arose the efforts of Ronalds, Sœmmering, and others; but the time was not fully ripe. The discoveries of Galvani, Volta, and Œrsted, however, combined with the result of preceding experience, led to the construction of the telegraphs of Gauss, Weber, Schilling, and Steinheil; and finally, the endeavours of Cooke and Wheatstone in England, and Morse in the United States, resulted in the production and general use of a reliable means of long-distance telegraphy, which has since been improved upon in many ways, but which, in its essentials, remains the same.

Now let us see what is the outcome of all this thought, inventive

genius, and intellectual energy. What has the thing they produced done for us?

Let us compare, say, 1837—when Cooke and Wheatstone first demonstrated the practicability of their system—with the facts of 1887.

In 1837, whenever a member of any family, however highly placed, left the shores of his native country, he was lost to his friends—he disappeared, as it were, from their lives. He might be heard of at more or less frequent intervals by correspondence passing through a slow post, but in no emergency, however great, could he be communicated with in time to admit of his taking prompt action; separation was realised and its real meaning felt. For instance, in 1834—and the conditions were little changed in 1837—when the first Melbourne Administration was dismissed by King William IV., a special messenger, despatched from Brighton on the morning of November 15th to Sir Robert Peel, then at Rome, could only carry to him the offer of the Premiership in ten days' time; making all possible speed he only arrived on November 25th.

At the present day let a man travel throughout the world, he holds in his hands, as it were, the strings communicating with his own home. Twenty-four hours, in practice, is an extreme period to elapse between the despatch of an urgent summons, or the communication of an important piece of intelligence, and its acknowledgment by the recipient, even at the ends of the earth. Last month Lord Hawke died at the St. Pancras Hotel. His son, and successor, was cricketing in Victoria, Australia, but in a few hours he received the sad intelligence, and will be home long before he could have known of the necessity for his return in the former state of things. Take the converse of this case. A criminal fleeing from justice wishes, of course, to cut off all traces of his connection with the place whence he flies. Fifty years ago he could do so easily; a few hours' law at the start would enable him to elude pursuit effectively. He could escape by sea and know that he could not be followed for a certain number of days, and that on his pursuers arriving at the foreign shore they would find him gone—vanished into the far-spreading regions of the West or South—where no clue could be found. Now let a man succeed in catching the fastest steamer that skims the ocean, and let him do so unobserved by his trackers here, he arrives at New York, Cape Town, Sydney, Melbourne, or Suez, only to find the police awaiting him, and ready to return him, by the quickest available means, to answer for his misdeeds.

In some quarters there is a tendency to question whether our modern improvements have really tended to increase the happiness of the world; whether there was not more real comfort when the pace was not so fast. A recent novelist has entitled one of his latest productons—the period of which is laid in the last century—"The World Went Very Well Then," implying, of course, that the present day is, at any rate, very little better: this is not the general feeling. There may be a germ of philosophic truth in it, but mankind does not, as a rule, govern itself by philosophic ideas. It may have been possible for a merchant of 50 years ago, who knew nothing of the changes of markets or of the political occurrences that had happened which might govern them, or affect speculative risks, save on the arrival of weekly, fortnightly, or monthly mails, to be content that he was spared the worry of concerning himself every day with such matters; but now the telegraph brings him daily or hourly news on all these points he has, at least, the advantage that no catastrophe can mature during his period of ignorance, and burst on him like a thunderstorm when the periodical notification arrives. Counting-house speaks to counting-house, not face to face, but in effect almost as if it were so. Orders have been despatched by post to be executed in London, and the goods sent to Calcutta: a turn of the market at the latter place shows that the execution of the orders will be a misfortune; the telegraph is employed and they are countermanded, no mischief being done. Shares that are held in various parts of the globe are suddenly greatly appreciated or depreciated at one of the great commercial centres: the facts are at once transmitted by wire to the others, and all markets are, at nearly the same time, placed on the same footing. The possibility of dealing rapidly in one centre, and of perhaps reversing the operation in another, is rendered under ordinary conditions, impossible; no such *coup* as that by which Nathan Rothschild gained £2,000,000, by his energetic exertions to secure early intelligence of the result of Waterloo, is now possible. To a large extent individual chances are equalised, at any rate, so far as they depend upon the securing of rapid knowledge of occurring events. It is argued that this is an evil to the smaller firms, that houses with a large command of means can bear the cost of communicating freely by wire, and thus the possession of capital tells more heavily than before in the race of competition against the lesser houses. There is some truth in the contention, but it is but one illustration of the general tendency of modern trade, which more and more shows that success in all the wider fields of commercial life is mainly secured by the operation of gigantic concerns working with vast resources, whether wielded by a single person or by an association. Individuals suffer in this struggle of competition, but the world at large profits by the increased magnitude of the aggregate business done; and the facility of rapid communication is not the least potent factor in bringing about the results we are witnessing.

In political matters the lightning messenger is not less powerful for good. Formerly, intelligence of some disturbance or menacing event was received at headquarters on a certain day, and nothing could be heard in reply, nor any direction given, until many successive events had transpired, and perhaps irremediable mischief had been done. In its early days, also, to put the telegraph in motion was of but doubtful advantage; the despatches were too brief, the orders were too curt—they were often misunderstood—rarely was their motive explained. In later times it has been found possible, on sufficient occasion, to exchange by telegraph despatches as full and clear as could be transmitted by letter, and thus no ground is left for the growth of misunderstandings that might produce international evil. Formerly irritated feelings grew up, and those whose duty and desire it was to soothe them were too late before they could apply any effective check to the popular passion that was urging either side into courses that could only culminate in war. The excitement that convulsed this country when Commodore Wilkes forcibly took the Confederate envoys from the mail steamer Trent, and very nearly brought two kindred nations into a miserable conflict—there being then no cable connecting England with the United States—and the speedy collapse of the fierce fever that overspread France this year, when the frontier squabbles with Germany culminated in the forcible arrest of Schnaebele, followed later by the unfortunate shooting of French sportsmen by Germans, are instances of the advantage of the telegraph being in existence. The statesmen on either side were enabled to promptly calm the feelings that threatened much at first, but speedily collapsed when the trifling character of the unlucky accidents was understood. Perhaps the ease with which directions can be transmitted from the centre of Government to colonial governors or military commanders should be admitted to have some drawbacks attaching to it. Of course the full circumstances of any special situation can only be known to those absolutely on the spot, and it is an evil when the transmission of too detailed instructions to them destroys the sense of individual responsibility in the officers commanding abroad. The telegraph makes much possible for the minister at home, but in some things discretion is best shown by abstinence from its too extensive use. Again, to take another form of superfluous energy as an example, it was, to say the least, unfortunate that, when the British and French armies were engaged in a life-and-death struggle with the Russian foe in an inclement winter in the Crimea, Lord Panmure, the then Minister for War, found the single wire laid between Varna and Sebastopol convenient for desiring the English Commander-in-Chief to "take care of 'Dowb'"—his relative, Major Dowbiggin.

News, in its widest sense, is a very different thing now than it was formerly. A newspaper of the earlier portion of this century contained intelligence from all quarters, no doubt, but it was not contemporary intelligence, nor at all regular in its appearance. From the nearer capitals of Europe it might perhaps be two or three days old only, but in the same journals that printed this news appeared articles from the more distant parts of the globe dated two, three, or even five months before. For instance, in 1837, in the *Times* of July 20th, there appeared news from Valencia, Spain, of Carlist operations on July 15th; the semaphore having been utilised for its transmission across France, but its news being broken off because darkness had come on. On July 26th, news was published from Rome dated July 16th. On the 28th of that month, the dates from Hamburg were July 23rd; but in the same issue Constantinople intelligence of July 7 was printed. From Quebec, news to the 3rd July did not appear until 3rd of August; and from New York, May 4th is the latest date mentioned on May 29th. From Tasmania, news to January 27th was not made known until May 30th. From the Cape of Good Hope, intelligence to March 25th was not published until May 30th; and on the same day Calcutta advices to January 27th appeared. Sydney letters of December 31st, 1836, were made public on June 8th, 1837; and, in the same paper, Batavia reports of December 28th preceding appeared. Buenos Ayres news of March 19th saw the light on June 13th.

In an earlier issue of that journal, under date of December 10th, 1834, appears a paragraph calling attention to an instance of unexampled rapidity of communication between Liverpool and New York, letters having crossed the Atlantic three times within 65 days. The vessels conveying them made unusually quick passages, and each departure took place within a few hours of each arrival, the correspondents taking advantage of them to despatch their communication without loss of time.

Since that period an entire change has appeared on the face of journalistic matters. If a cricket match takes place at Sydney, New South Wales, on December 10th, the full score appears in *The Times* on the morning of December 12th, the intervening day being Sunday, but 10 hours being represented by the difference of time between the longitudes of Sydney and London. On December 23rd, a resolution of the New Zealand House of Representatives, on the subject of Colonial Defences, dated December 22nd, appeared in the first edition of the same journal. And on December 31st, a message appeared in the second edition of the *Globe*, printed at 12.30 p.m., dated the same day giving the substance of Mr. Chamberlain's speech at a banquet at Toronto the previous night. If despatched at 6 a.m., the difference of time alone would make it 5 hours later before it could reach London.

Not only events of mighty import to the interests of nations, but records of comparatively trifling matters—the appearance of a popular actor, the result of a boat race, and the like—are flashed across the world, and published here as they would be had they transpired in some city of our own island. The world has indeed become very small, if its dimensions are to be measured by the rapidity of knowledge in one part of the facts that occur in another.

Again, as regards our country alone, a most remarkable change has occurred in the character of the press. Fifty years ago the most important speeches might be delivered a few hundred miles from London, and they appeared in the shape of a meagre, condensed summary the second or third day after delivery. There were no longer new when they could appear at all, and hence it was not worth while publishing them at length when they did appear; perhaps, however, this imperfect publication had the compensating advantage of lessening their frequency, so far as readers were concerned. Now, if Mr. Gladstone speaks in Midlothian, Lord Hartington at Dublin, or Lord Salisbury at Liverpool—although it may be close on midnight before their oratorical efforts are completed, yet next morning the broad sheets of our daily press will give us, verbatim, all that their audiences have listened to; and, in fact, the readers of London papers often know much earlier than the residents of a village ten miles from the place where the discourses were delivered what were the very expressions of the distinguished speakers.

It is not, at the present day, conditions of time or distance that limit the fulness with which an oration appears the morning after

delivery in the newspapers but only the amount of popular interest which the conductors of each particular journal believe will be taken by its readers in the speaker's words. Audiences are no longer confined to those who can be present in the largest halls; on the wings of the telegraph, and by the agency of the newspapers, the speaker addresses the whole world, or at least such portions of it as care to know his opinions on the subject of which he speaks.

The use of the telegraph is not at all in proportion to the population of the various localities it serves. Much depends upon the nature of such populations, on the avocations in which they are mainly engaged, and the extent to which fluctuations are liable to occur in prices of the commodities in which they are interested. A certain constant quantity, as it may be considered, of telegraphic business arises from the needs of domestic life. This is common to all centres, but necessarily varies as the class of the inhabitants varies. From the east of London, for example, 500,000 residents have occasion to communicate by wire on their ordinary affairs much less frequently than a corresponding number of residents in the west. Speaking as a general rule, the operative classes of the community have less widespread interests than those placed higher in the social scale. They receive in relation to their numbers fewer letters per head, and send fewer telegrams. The employment by them of the speediest engine of communication is decidedly on the increase, but it has still great room for growth.

London is far and away the centre of greatest telegraphic activity; but the fact of its being the capital—the seat of the Legislature and of the Law Courts, the headquarters of the Stock Exchange, and so on—gives it so many special features, independent of its widespread commercial interests, that it can hardly be properly compared with any provincial town as regards the amount of business done. It may, however, be of some interest if I contrast a few of the leading provincial towns in this respect.

Taking the calculated population within the free town deliveries of letters up to the end of 1886, and the actual number of telegrams originating within the same limits for the year ending September 30th, 1887, the results are as follows:—

	Population.	Telegraph Messages.
Glasgow	740,000	1,444,741
Liverpool	730,000	2,268,062
Manchester	613,982	1,660,538

exclusive in all cases of the messages collected from America and the Eastern Telegraph system, which are despatched by special wires worked by the cable companies. Upon these figures it should be remarked that the population attributed to Glasgow includes the ring of minor boroughs excluded from the city in a municipal sense. In the case of Liverpool all north of the Mersey is reckoned, but Birkenhead, largely peopled by persons interested in Liverpool commerce, is excluded. But the fact remains that the seaport possessing the largest trade of any, out of London, in the kingdom, does the largest telegraphic business. Manchester includes Salford in its number of residents, and, being a central point for numerous surrounding towns who look to it for guidance in commercial matters, ranks considerably above the larger population of Glasgow as regards the employment of the telegraph. Further—

	Population.	Telegraph Messages.
Birmingham	420,000	672,714
Edinburgh (with Leith) ...	319,030	667,758
Dublin	319,000	582,083
Newcastle-on-Tyne	151,500	546,294
Bristol	227,127	466,412
Hull	186,290	452,921

show the comparative telegraphic pre-eminence of the seaports as compared with the subordinate capitals and the great Midland manufacturing centre. Edinburgh, including Leith in its boundaries, adds thereby a place of material commercial activity to its semi-metropolitan population.

Other cases strengthen the conclusion that the nature of the trade rather than the absolute volume of business must be considered in determining this comparison, thus—

	Population.	Telegraph Messages.
Leeds	296,108	337,998
Belfast	225,000	344,603
Sheffield	305,000	257,056
Nottingham...	211,424	236,143
Leicester	127,506	188,890
Cardiff	115,000	394,891
Dundee...	152,840	206,168
Aberdeen	113,212	206,680
Newport (Monmouth) ...	40,000	153,193

For most of these divergencies and discrepancies, persons familiar with the characteristics of the various towns will easily find reasons; and I may add a few more instances:—

	Population.	Telegraph Messages.
Portsmouth	132,659	154,905
Plymouth (*ex* Devonport) ...	96,142	185,454
Southampton	61,000	158,069
York	60,500	126,541
West Hartlepool...	32,000	114,014
Oxford	44,000	86,524
Chester...	40,340	98,721
Bath	57,000	81,126

Analysing the figures given above, we find that Liverpool, with rather more than three messages per annum per head, Newcastle-on-Tyne with rather more than 3½ messages per head, Cardiff with somewhat less, Newport (Monmouth) with an approach to 4 messages per head, and West Hartlepool with about 3½ messages per head per annum, rank highest among English towns as contributors to telegraphic employment. It may be remarked that Oldham and Blackburn, both containing over 100,000 of population do not figure in the list of the 52 towns whence the greatest number of messages are forwarded, although many much smaller places do.

In some instances apparently extraordinary results are explained by local facts. Thus, the 60,500 residents of York apparently do much more business than the 91,000 inhabitants of Norwich, a city of the same general character (126,000 messages to 89,000); but probably the circumstance that two important race meetings are held at the former place, and the great railway station there is far more important to the travelling community than any at Norwich, may account for the distinction. If it were possible to analyse the apparent discrepancies between the figures of other towns, no doubt there would be some similar means of explaining them.

This much may serve to illustrate the changes that the electric telegraph has wrought, and the benefits it has conferred.

(*To be continued.*)

THE CITY COMMISSION OF SEWERS.

At a meeting of the City Commission of Sewers held at the Guildhall, on Tuesday, Mr. Graham King presiding, a report was brought up from the Streets Committee, submitting for adoption a proposed arrangement with the Anglo-American Brush Electric Light Corporation for lighting a district of the City by means of electricity. It stated that for nearly four years the committee had been in negotiation with that company in reference to various proposals for the electric lighting of a portion of the City on the principle of their being afforded facilities for lighting the private premises on their line of route, and they now submitted a draft contract for lighting the district commencing from the front of the Royal Exchange, and comprising so much of the City as lies between the Poultry, Cheapside, St. Paul's Church-yard, Ludgate-hill and Fleet-Street, on the north and Queen Victoria-street and the Embankment on the south. It was proposed to have 169 arc lamps of 2,000 candle power at £26 each per annum, or £4,394 in all, in place of 616 gas lamps costing £2,246, the total illuminating power of the arc lamps to be about 32 times that of the present gas lighting. In the narrow parts and courts glow lamps or arc lamps of less capacity and in greater number might be substituted at an additional cost of 50 per cent. and 25 per cent. respectively. The contract was for seven years, with power to the Commission to continue it for further periods of seven years, so long as they did not grant to other companies powers in regard to private lighting within the district. The contract might be terminated after notice in writing of insufficiency of lighting and non-remedy by the company for a month. The Commission would grant to the company the exclusive right to supply private lighting, and if they terminated the contract as to public lighting the company were to be at liberty to continue their private lighting.

Mr. J. C. Bell, in moving the adoption of the report, spoke of the great importance of the matter, and observed that, unless the Commission gave some such stimulus as was proposed in the report, electric lighting in the City must be inoperative for some time to come. The cost would not be more than twice the present cost of gas, while they would have 32 times more light. There was a very general desire on the part of the ratepayers for the introduction of the electric light, and the district in question would be lighted at a cost of not more than ¼d. in the pound to the rates. The City was well lighted as it was, but compared with Paris and other Continental cities, where the electric light was in use, it was very badly illuminated. The committee had earnestly considered the question of lighting the whole of the City, but the cost of lighting the small by-streets made it very expensive. No doubt they were creating a monopoly, but unless some such concession was given they could not hope to have electric lighting in the City.

Mr. W. H. Pannell, though strongly in favour of having the electric light, urged that some stringent forfeiture clauses should be inserted in the contract. The Commission had had some experience in the matter, and had seen their agreements with other companies used entirely for Stock Exchange purposes, and without any consideration for the public interest. In the proposed agreement the Company were to be at liberty to continue the private lighting, although they may not be able to continue the lighting of the public lamps, which, it was admitted, would be supplied at a loss to the Company. Thus the Company, immediately they obtained the monopoly, would have the power of repudiating their agreement to supply the public lamps. Again, the Company would not be bound to supply all who desired to have the light, and they could charge exactly what they liked. He moved that the report be referred back to the committee for further consideration as to the points he had mentioned.

Mr. C. T. Harris advised the Commission to exercise particular caution in the matter.

Mr. F. Green remarked that if the chairman of the committee would consent to insert a forfeiture clause the Commission were practically agreed upon the report.

Mr. J. C. Bell, in reply, said they were bound to take some risk in the matter. He thought the fact that the Company would have to expend a large sum in laying down their plant should be a sufficient guarantee. No company would consent to the insertion of a money penalty forfeiture clause. Electric lighting had been sufficiently handicapped by Act of Parliament without the Commission throwing obstacles in the way.

The amendment of Mr. Pannell was carried by 20 votes to 8, and the report was referred back for reconsideration.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.	Dividend.		Name.	Paid.	Price. Wednesday
3 Jan.	4%	African Direct 4%	100	98 to 100	1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105
12 Feb.	1/2	Anglo-American Brush E.L.	4	3	25 July	10/0	India Rubber, G. P. & Tel.	10	$22\frac{1}{4}$
12 Feb.	2/0	— fully paid	5	$4\frac{1}{4}$	28 Oct.	12/6	Indo-European	25	39
28 Oct.	7/6	Anglo-American	100	38	16 Nov.	2/6	London Platino-Brazilian...	10	$4\frac{1}{2}$
28 Oct.	15/0	— Pref.	100	63	16 March ...	5%	Maxim Western..............	1	5-11
12 Feb., 85...	5/0	— Def......................	100	14	15 May	5%	Oriental Telephone	11	$\frac{3}{8}$
29 Dec.........	3/0	Brazilian Submarine.........	10	$12\frac{1}{8}$x	14 Oct.	4/0	Reuter's	8	$8\frac{1}{2}$
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	$3\frac{1}{2}$	$1\frac{3}{8}$
28 July	8/0	Cuba	10	$12\frac{3}{4}$	28 July	12%	Submarine	100	135
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	97
14 Oct.	1/0	Direct Spanish	9	$4\frac{1}{4}$	14 July	12/0	Telegraph Construction ...	12	$38\frac{5}{8}$
18 Oct.	5/0	— 10% Pref.	10	$9\frac{1}{2}$	1 July	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	$9\frac{1}{4}$	30 Nov.	5/0	United Telephone	5	12
14 Oct.	2/6	Eastern	10	$11\frac{1}{8}$	......	...	West African	10	5
14 Oct.	3/0	— 6% Pref.	10	$14\frac{3}{4}$	1 Sept.	5%	— 5% Debs.	100	93
2 Aug.	5%	— 5%, 1899	100	109	29 Dec.........	6/0	West Coast of Africa	10	5x
28 Oct.	4%	— 4% Deb. Stock	100	$102\frac{3}{4}$	30 June	8/0	— 8% Debs.	100	114
14 Oct.	2/6	Eastern Extension, Aus-			14 Oct.	3/9	Western and Brazilian......	15	9
		tralasia & China...........	10	$12\frac{1}{4}$	14 Oct.	3/9	— Preferred	$5\frac{1}{2}$	$6\frac{1}{8}$
2 Aug.	6%	— 6% Deb., 1891	100	109	......	...	— Deferred..................	$2\frac{1}{2}$	3 3-16
3 Jan.	5%	— 5% Deb., 1900	100	105x	2 Aug.	6%	— 6% A	100	108
2 Nov.	5%	— — 1890	100	102	2 Aug.	6%	— 6% B	100	105
3 Jan.	5%	Eastern & S. African, 1900	100	103x	......	...	West India and Panama ...	10	1
30 March ...	6/3	German Union	10	$9\frac{3}{4}$	30 Nov.	...	— 6% 1st Pref.	10	10
14 Oct.	0/6	Globe Telegraph Trust......	10	5 7-16	13 May, '80...	...	— 6% 2nd Pref.	10	$6\frac{1}{2}$
14 Oct.	3/0	— 6% Pref.	10	$13\frac{1}{2}$	2 Nov.	7%	West Union of U.S.	$1,000	125
3 Jan.	5/0	Great Northern...............	10	14x	1 Sept.	6%	— 6% Sterling	100	104

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Nov. ...	£39,000	+ £2,261
Brazilian Submarine	W. Jan. 11 ...	£4,491	...	Great Northern	M. of Dec. ...	21,600	...
Cuba Submarine	M. of Nov. ...	3,000	+ £420	Submarine	None	Published.	
Direct Spanish.....................	M. of Dec. ...	2,004	+ 222	West Coast of America	M. of Dec. ...	4,300	...
— United States	None	Published.	...	Western and Brazilian	W. Jan. 11 ...	3,613	...
Eastern............................	M. of Dec. ...	57,703	+ 4,880	West India and Panama	F. ½ Dec. 31 ...	2,826	– 263

Abbreviations: W., week; F., fortnight; M, month.

NEW ELECTRICAL COMPANIES, 1887.

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Shares.	Deposit.	Total Deposit.
Blockley Electric Lighting and Manufacturing....................................	£20,000	...	£5 0 0	...	...
Eclipse Electric Battery, Limited	100,000	£100,000	1 0 0	£0 10 0	£50,000
Electric Battery Brush, Limited	50,000	50,000	5 0 0	1 0 0	10,000
Extended Electro-Metal Extracting, Refining, and Plating, Limited	150,000	150,000	1 0 0	0 5 0	37,500
Jensen Electric Bell and Signal, Limited	100,000	100,000	1 0 0	0 6 0	37,500
Orient Electric Light..	5,000	...	250 0 0	...	...
Platinum Plating, Limited	60,000	59,100	1 0 0	0 5 0	14,775
Portland Electric Light...	45,000	...	5 0 0	...	...
Singapore, Straits Settlements, and Siam Electrial, Limited..................	60,000	39,000	5 0 0	2 0 0	15,600
South Metropolitan Electric Supply	250,000	...	10 0 0	...	...
St. James's Electric Light, Limited	50,000	50,000	5 0 0	2 0 0	20,000
Union Electrical Power and Light, Limited	500,000	125,000	5 0 0	2 0 0	50,000
Winfields, Limited	160,000	120,000	5 0 0	3 0 0	72,000
Woodhouse and Rawson, Limited	200,000	105,000	5 0 0	1 0 0	21,000

CITY NOTES.

Financial.—Owing to the success of the Anglo-Cables in their legal proceedings against the French Cable Company a rise in the shares has taken place during the week. A rise also is recorded in Anglo-Brush shares.

New Company.—The Platinum Plating Company (Limited) is a new company with a capital of £60,000, in 59,100 ordinary shares of £1 each, and 900 founders' shares. The present issue is of 59,100 ordinary shares. The objects of the company are stated to be to acquire patent rights for, and to introduce throughout the United Kingdom of Great Britain and Ireland, the Empire of India and the British Colonies (Canada excepted), a discovery believed to be of great value, whereby platinum can be successfully deposited upon all descriptions of articles made of brass, copper, steel, or other metals, with a brilliancy of surface and colour hitherto unattained.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the past week amounted to £4,491, and those of the Western and Brazilian Company, after deducting the "fifth" of the gross receipts payable to the London Platino Brazilian, were £3,613.

NOTES.

Iron-clad Dynamos.—Mr. J. Wenstrom claims priority in the design of these dynamos.

Halifax.—The Halifax Football Club has had its ground furnished with the electric light. The field is surrounded by arc lights suspended from high masts.

Japan.—The electric light is becoming increasingly popular in Japan. A number of lights have now been fitted up at Sakamotocho and Kyabacho, Tokio.

Appointment.—M. A. Bandsept, of Brussels, has been appointed engineer-in-chief for the electrical and lighting departments at the Grand Concours Exhibition during the present year.

Time Regulation.—At a recent meeting of the *Académie des Sciences* M. Cornu read a description of an improved arrangement for synchronising clocks and transmitting time indications.

Society of Arts.—Two lectures will be delivered by Prof. O. J. Lodge, D.Sc., F.R.S., on the "Protection of Buildings from Lightning," on Saturday afternoons, March 10th and 17th, at three o'clock.

The New Telephone.—Like the apparatus of other companies, the New Telephone is being employed in large works instead of speaking tubes. Mr. T. H. P. Dennis has taken the agency for Chelmsford.

Dundee.—A sum of nearly £1,000 has been subscribed for the proposed Victoria Art Gallery. The estimated cost is between £9,000 and £10,000, and a further sum to carry out the intention to illuminate the rooms with the electric light.

The "Himalaya."—Readers of the daily papers will know that this transport in going out of harbour fouled the mooring chains of a buoy with her propeller. A staff of divers, assisted by the electric light, enabled the vessel to be cleared.

Secondary instead of Primary Batteries.—The Exchange Telegraph Company have replaced 2,000 primary batteries by 210 "E.P.S." accumulators. It is expected that this successful experiment will lead to a greater use of storage batteries for telegraphic and telephonic work.

Electro-Harmonic Society.—The next smoking concert of this society will be held at the St. James's Hall Restaurant, Jan. 27, at 8 o'clock. A good programme has been arranged by the musical directors—Messrs. Gatehouse and Thompson—in which the following artistes will take part:—Messrs. Walter Coward, Arthur Thompson, James Kift, Musgrove Tufnail, C. Hann, and Alfred Izard.

A Portable Cell.—Mr. Cox has suggested the use of gelatine instead of a liquid in a cell which has to be carried about. To the prepared gelatine, salammoniac or other salt used is uniformly mixed with the gelatine. When the mass is thus prepared a little bisulphate of mercury is added, which improves the electrolyte and keeps the zinc amalgamated, and the whole preparation is then packed around the electrodes.

Tar or Coal.—Some of our contemporaries are carried away by any new suggestion, and the design of a new thermo-engine to burn tar is supposed to be the thin wedge that will soon oust all steam-engines burning coal from the market. Have those who foretell these changes asked themselves the question, how the price of tar, creosote, etc., would compare with coal if the demand for tar approached anything like the proportions of that for coal?

Telephone Trunk Lines.—The construction of the telephone between Dundee and Kirkcaldy *vià* Tayport was completed last week, and as Kirkcaldy is already connected with Edinburgh and Glasgow, telephone communication from Dundee is now greatly extended. After the connection had been made, the operators at Dundee exchanged the compliments of the season with the officials in Kirkcaldy and Stirling, and afterwards with those in the Glasgow and Edinburgh offices.

Electricity in the Classics.—It is well known that many people are easily susceptible of a static charge of electricity, and it may be a phenomenon of this kind that Virgil refers to when he mentions the harmless flame emitted by the hair of Ascanius—

"Ecce levis summo de vertice visus tuli
Fundere lumen apex, tactuque innoxia molli
Lambere flamma comas, et circum tempora pasci
Nos pavidi trepidare metu, crinemque flagrantem
Excutere, et sanctos restinguere fontibus ignos."

Telephonic Millenium.—The *Western Morning News* seems anxious to arrive at the epoch when a telephonic talk, like a letter, will be carried for a penny. Our contemporary kindly informs us the time is fast coming, "but probably it will not dawn until all the telephonic patents have become public property." The happy time to come when the "telalogue" is to be one penny depends upon other questions than who possesses the patents. Time and space have to be considered—how long and how far for a penny?

Canada.—The Canadian railways are experimenting with the electric light. It is singular that, with one or two exceptions, so little is done by our railway companies to improve the lighting of their carriages. Local trains are mostly patronised by business men who live away from the factory or warehouse. Many of these business men would be glad of a light that would enable them to comfortably read the paper in the evening as they returned from business. Time is of so great importance nowadays, that many could usefully employ the time spent in the railway carriage if the light given was sufficient, instead of being only just enough to make darkness visible.

Journal of the Society.—The current number of the *Journal* contains papers on "Deep-sea Soundings in Connection with Submarine Telegraphy," by W. E. Stallibrass, on "Some Instruments for the Measurement of Electromotive Force and Electrical Power," by Prof. J. A. Fleming and W. C. H. Gimingham; and one on "Portable Voltmeters for Measuring Alternating Potential Differences," by Profs. Ayrton and Perry, besides an original communication by Mr. A. E. Kennelly on the "Superiority of the Earth-overlap Method Localising Small Faults in Cables;" and a number of abstracts and titles of electrical papers. It will be seen that the number contains a variety of interesting matter.

Electrical Dissipation of Smoke.—It is said that the discovery by Professor Lodge of the curious effect of discharges of static electricity upon dust and vapour has been taken advantage of by Mr. J. G. Lorrain in the construction of an apparatus for the dissipation of smoke resulting from the discharge of ordnance. Mr. Lorrain proposed to employ an electrostatic generator, such as Wimshurst's, in communication with appropriate con-

ductors arranged around the mouth of the gun, and as a conductor he prefers a light wire lattice provided with points. It is possible that such a device may be successful, but trials on a full working scale will be necessary before any definite opinion can be expressed.

Dublin.—It is well known that the Dublin Corporation are considering the question of utilising the water-power in their possession at Island Bridge for an experiment in electric lighting. Island Bridge is about two miles from the streets it is proposed to light, and the water-power available is estimated at 50 h.-p., which is expected to be sufficient to obtain a current for 45 arc lamps, each of 2,000 c.p. nominal. Estimates were advertised for last November, the specification having been prepared by the city engineer, but only three tenders were received in response, and neither of these has been deemed satisfactory. The municipal authority has therefore ordered that further estimates be advertised for, and it is expected the advertisements will appear immediately.

Alternate Currents.—There is a growing disposition to use alternating currents with transformers, and if the Thomson-Houston system in this direction is as successful as in arc lighting their competitors must look to their laurels and to their pockets. According to American advices the Thomson-Houston Company is doing a large business with its alternating system of incandescent electric lighting. The demand is so good and constant that a stock of apparatus for the distribution of energy for lighting by alternating current, including dynamos, of capacity from 250 to 1,000 lights, the necessary transformers, potential and current indicators, together with a complete system of feeder boxes, junction switches, and all other devices necessary is kept to supply urgent orders.

Electrical Symbols.—In *l'Electricien* of the 7th inst. M. E. Hospitalier states that he has been unsuccessful in his endeavours to introduce, through the intermediary of the *Société Internationale des Electriciens*, a universal system of notation and symbols in electrical science, one important result of which would be a great saving of space and time by avoiding the necessity for defining the symbols for the values most frequently referred to in this science. He gives, however, the notation, abreviations, and symbols, extending over nearly five pages, which will henceforth be adopted in the paper under his editorship. We observe that the symbol for work and energy is W, and in many other cases the symbols adopted are those in common use in this country. The symbol for current, however, is I, instead of C, which is now almost always adopted here.

The Tudor Accumulator.—This form of secondary battery, which is somewhat analogous to that of M. Somzée, has been tested with satisfactory results in Germany and Luxembourg. The principle of its construction is said to be the adoption of central supports of which the section is a cross, thus obtaining great rigidity and facilitating the application and retention of the active material. But the point of greatest novelty in the manufacture of the battery is the "forming" of the lead supports by the passage during several days of currents alternately in opposite directions, according to the method of Gaston Planté. Thus a *liaison* is obtained between the metallic conductor and the layer of active material subsequently applied, and it seems probable that the connection so established would be more perfect than that due to the comparatively very thin layer of peroxide and spongy lead formed on the surface of the supports in the ordinary process of charging.

A Long Streak of Electricity.—The Jenney Electric Company yesterday received a telegraphic proposition from Auckland, New Zealand, which contained seventy words, and cost the sender \$2.71 for each word. It is interesting to note the line of travel followed by this message in reaching its destination. The first repeating station was at Wellington, thence to Sydney, Australia, thence across the country to Palmerston, from there *viâ* cable to Saigon, Siam, then to Calcutta, thence across Hindostan to Bombay, from there under the Arabian Sea to Mocha, thence up the Red Sea to Mount Sinai, thence across Egypt to Alexandria, then to Palermo; from there under the Mediterranean to Gibraltar, thence to Lisbon, London, Queenstown, New York, and Indianapolis. To fill the order, Brainard Rorison says, would test the capacity of their works for one month, and the reply, "Impossible; factory overloaded," was reluctantly sent.—*Indianapolis Daily Journal.*

Output of Bell Instruments.—The output of telephones by the Bell Company for the month and year ended December 20, is appended with comparisons:—

Month Dec. 20.	1887.	1886.	Increase.
Gross output	3,486	3,946	*460
Returned	2,094	1,686	408
Net output	1,392	2,260	*868
Since Dec. 20.	1886-87	1885-86	
Gross output................	52,156	42,306	9,850
Returned	26,789	19,924	6,865
Net output...........	25,367	22,382	2,985

*Decrease.

This makes the number of telephone instruments in the hands of licensees December 20th, 1887, about 378,885, against 353,518 in 1886, 330,040 in 1885, 325,574 in 1884, 298,580 in 1883, and 237,728 in 1882. The gain in 1886 over 1885 was 23,478.

Blackfriars-road.—Upon the recommendation of the Roads Committee of the St. George's Vestry, it was resolved "that the application of the Anglo-Brush Co., for permission to lay electrical conductors under the footway on the west side of the Blackfriars-road, according to plans to be approved by the vestry, and offering to supply the electric light to the inhabitants of the Blackfriars-road upon the same terms as the current is supplied elsewhere by the company, be granted upon condition that the company enter into an agreement to be prepared by the vestry's solicitor, all costs and charges of such agreement to be paid by the company; that before breaking up the pavement notice be given to the vestry, and the reinstating of the pavement be done to the satisfaction of the vestry's surveyor; that a nominal rent of five shillings per annum be paid to the vestry by the said company; and that all expenses of, and incident to, the carrying out of the above from time to time be paid by the said company, and the contract be terminable by six months' notice on either side."

Electric Lighting at York.—Messrs. Rowtree, Hills and Co., of York, have recently adopted the electric light in their shops. The installation, which has been carried out by Messrs. J. H. Holmes and Co., Newcastle-upon-Tyne, consists of one of their No. 8 "Castle" dynamos (compound wound) giving 70 amperes 60 volts, at a speed of 1,000 revolutions, driven by a 6 horse-power "Stockport" gas engine. The shops are lighted by 9 of Holmes' "Castle" arc lamps, which received a silver medal, the highest award at the Newcastle Exhibition, and 5 small ones giving 400 candle power with a current of 5 amperes. The offices at the back of the premises are lighted with 60-

volt Swan lamps. The arc lamps employed in this installation are of Messrs. Holmes and Co.'s new and improved type, including their recently patented arrangements for ensuring a definite feed and thus regulating the lamps with great certainty. The creamery is elaborately panelled with decorated tiles, and the small arcs in this department give a charming effect.

Alloys. — Mr. Warren recommends an electrolytic method for the preparation of certain alloys such as sulphur-bronze, silicides, &c. The metal and substance containing alloying material are placed in a deep conical crucible, through the bottom of which passes a rod of graphite, extending about one inch within the crucible and protected on the outside by an iron tube. The metal is melted and the graphite is put in connection with the negative pole, whilst the molten substance on the surface is connected with the positive pole of a battery of two large ferric chloride cells. In this manner silicon-copper and silicon-eisen are easily prepared from potassium silicofluoride and the respective metal; the salt being taken in sufficient quantity to form a molten layer two inches deep. By some slight variation in the details, phosphor-bronzes can be produced; moreover, native cryolite can be decomposed in contact with metallic zinc, and on subsequently volatilising the zinc, pure aluminium is obtained. Magnesium, barium, strontium, and calcium have not yielded satisfactory alloys as yet.

Copper.—Now that copper, which is so largely used in electrical work, has reached its present price, inquiry has naturally arisen as to the extent to which production can and will be increased. Our contemporary, *Iron Age*, a leading authority on these questions, taking a careful survey of the situation, remarks: "On the whole, production of copper is not so elastic as many might be inclined to believe. The product will certainly increase quite rapidly, but the amounts thrown upon the market by mines which have been idle for years will be small for six month to come. We look for the principal increase from those producers who have found 10 to 12 cents above the cost at which they could deliver the metal into consumers' hands." In other words, the return to normal values will be slow. We are a little interested to see what effect the higher price of copper is going to have in causing resort, where possible, to other metals that are cheaper, but are of less conductivity. The situation is certainly one that gives emphasis to the claims of superior economy made for the alternating system, and will encourage generally the use of higher potentials.—*Electrical World.*

The Ampere-Standard (Ampere-Etalon) of M. Pellat.—This instrument is a balance-electro-dynamometer similar to the absolute dynamometer submitted to the *Société Française de Physique* by the same *savant* about a year ago, but of smaller dimensions. It measures the intensity of a current by the number (f) of grams which, when placed in the scale-pan of the instrument, will balance the electro-dynamic couple produced by this current. The formula employed is

$$C = k\sqrt{f},$$

in which k is a constant for a given locality, which is independent even of temperature, and which, for any other locality, varies as the square root of the intensity of gravitation. This constant is determined once for all by a comparison with an absolute electro-dynamometer. The sensibility of the balance is such that it will, with the aid of the microscope, indicate a difference of $\frac{1}{30}$ milligram. Thus, since a current of ·5 ampere is balanced by 1500 milligrams, f may be determined to $\frac{1}{75000}$; and, since C varies as $\sqrt{f}$, the limit of error does not exceed $\frac{1}{150000}$. The apparatus allows of the calibration, by derivation or otherwise, of all instruments intended for the measurement of currents in practice.

Meteorological Society.—At the annual general meeting of this society, held on Wednesday at the Institution of Civil Engineers, 25, Great George-street, Westminster, Mr. W. Ellis, F.R.A.S., president, in the chair, the report of the council showed that the society was in a satisfactory condition, the number of Fellows being 522. Mr. Ellis, in his presidential address, reviewed briefly the work and position of the society. He remarked that, although they were unable to carry out expensive original or experimental work, they could act with great advantage in inciting volunteer workers throughout the country to united action. One recent example of this was the ready response to the request of the society for photographs of lightning. An excellent collection of photographs had been obtained and would shortly be exhibited. Arrangements were also being made for the more systematic observations of thunderstorms. Referring to the question of sympathetic relation between sun spots and magnetism and meteorology, he thought that any complete treatment of the question in its meteorological aspect seemed to require that it should be dealt with in a much more comprehensive manner than before. For this purpose observations more completely covering the surface of the globe might be necessary.

Electric Lighting at Lucerne.—The Schweizerhof Hotel is now entirely and splendidly illuminated by electricity. Incandescent lamps have been fixed in the passages, cellars, kitchens, and bed rooms, even to the garrets situated on the fifth floor. At any hour of the day or night these can be brought into operation merely by pressing a button. Both the arc and the incandescent lamps act with the most perfect regularity, never becoming extinguished or varying in the intensity of the light. Within the interior of the hotel there are no machines nor space occupied, nor staff to superintend the lights. The electrical supply enters the building by the wires from the works of Gebrüder, Troller and Co., situated at Dorenbourg, about seven kilometers west of Lucerne. These works supply not only the hotel installation, but many others, the total number being 2,000 incandescent and 15 arc lamps. The installation was carried out by Ganz and Co., of Pesth, on the Zipernowski system. The turbine, made at the works of Bell and Co., at Kriens, is of 125 horse-power. The hydraulic power itself is nearly 250, and by increasing the fall from 7 to 18 metres might be increased to 450 horse-power. In winter when, by reason of hard frost, the hydraulic power cannot be utilised, the turbine is replaced by a steam engine of 150 horse-power. The superintending staff is composed of five workmen, of whom three are at work in the day and two in the night time.

Irish's Electric Railway System.—In attempting to overcome the disadvantages of the overhead and conduit systems of electrical transmission to the cars of street railways, a Cleveland gentleman has conceived the idea of a conduit that will need no drainage, will exclude all moisture and remain closed and sealed at all times, yet at the same time it will admit of an electrical connection being made by the proper mechanism. The arrangement is to lay two

channels in the pavement, the sides of which are just below the street grade. Each of these channels carries one of the conducting wires from the dynamo. The conduit or channel is made of soft rubber, and affords the only insulation that is supplied to the wires. Attached to the conduit along its upper surfaces there are short rail pieces, which rest on shoulders on the top, and which, when in their normal position, are flush with the level of the street. Inside of the tube and corresponding to the rail pieces there are short strips of contact pieces, which are insulated from the rail strips except where they are firmly united by screws. The action of the device is as follows:—Underneath the car there are contact wheels with a concave rim which run upon the rails of the conductor. They are pressed down by a spring of sufficient tension to overcome the resistance of the rubber conduit. The elasticity of this rubber is all that is depended upon to hold the contact pieces away from the wires. As the rails are independent of each other, they can be pressed down upon the wires, one after another, as the car passes. It is this contact that furnishes the electricity for the propulsion of the car. The stream is continuous, as one of the sections is not freed from the contact until the next one has been pressed down. The conductors at the bottom of the tube are coupled together by means of a variable expansion joint, which will allow of expansion and contraction of the sections composing the conductors, under varying temperatures. The motor, designed by the same inventor, is very flat, and is intended for use under the body of the car.

Electric Outposts.—Some information was recently published in the *Pittsburgh Gazette* respecting a discovery by Daniel Drawbaugh, whose right to priority in the invention of the telephone will soon be decided upon by the Supreme Court of the United States. He has almost completed an insignificant little piece of electrical mechanism that may have an important bearing on the warfare of the future. It consists of what Mr. Drawbaugh calls a microphone and registering dial. The microphone is placed in a hollow iron tube, which is hermetically sealed. When it is to be used on land the microphone is attached to an iron screw with a very wide thread, by means of which it is sunk firmly into the earth. An insulated wire connects with a galvanic battery and registering dial, which may be placed miles away. The registering dial is surmounted by a needle that works from zero point. Underneath the dial, in the small circular brass box that it covers, is another needle in the form of a working beam like those seen on side-wheel steamboats. When the vibrations of sound, either by the medium of earth, water, or air waves, affect the microphone, the needle beneath the dial dips. The dipping puts one end of the steel into a pot of mercury, and a new local current of electricity is started, which moves the needle on the face of the dial and serves to give the alarm. The practical working of the instrument is intended to assist the picket lines of an army. It is hoped that a commanding officer may sit in his tent, supplied with a registering dial, and be kept informed of the approach of a large body of troops from any direction by a proper distribution of the stakes containing the hermetically sealed microphones, a dozen of which may be used as the situation demands. The instant the air or earth vibrations caused by the tramp of feet or the sound of voices affect the microphone, that instant the effect is shown on the face of the dial by the turning of the needle from the zero point. It may not be known to Mr. Drawbaugh, it may not be known to many of our contemporaries, that the microphone has long been used to record earth vibrations. The indefatigable young men who made a strong attempt to move the centre of the scientific world from Europe to Japan, buried microphones in all directions to record seismic vibrations, and found that other vibrations were recorded.

An Electric Chess Recorder.—A very ingenious and novel electric machine for the automatic registration of the moves made during a game of chess has been invented by Dr. Würstemburger, of Zurich, and is now on view at the office of Messrs. Woodhouse and Rawson. The invention consists of two parts, the chess board and the recording machine. The board is, to all intents and purposes, an ordinary chess board, the men fitting by means of feet into circular holes made in the centre of each square. The under side of the board is fitted with wires connecting with the recording machines, and the insertion of a piece in any particular hole makes the contact complete, and starts the current, which is broken on a piece being lifted. The recorder consists of a motor driving a printing wheel, to which is attached a series of small brushes acting on a commutator, to a section of which each square of the board is electrically connected. The printing mechanism is acted on by an electric magnet, which is brought into play by the brush passing over the particular section of the commutator to which the squares upon which the piece is moved belong. A very ingenious portion of the invention is the method by which the difference in the marking of the black and white moves is recorded. This is accomplished by means of a switch coupled up to the wires connecting the black pieces, which when brought into play throws the two lines of type further apart, showing the difference between the white and black moves at a glance. The recorded moves appear on an ordinary telegraph tape, and the whole is perfectly automatic in its action. The apparatus exhibited—the only one yet made—is, as might be expected, rather an example of inventive ingenuity than a practical instrument, the cost of the machine being sufficiently high to prevent its coming into general use. We understand that the instrument has cost £80 to make, but its working is sufficient to show the feasibility of the idea, and we shall be glad to hear that its capabilities are to be tested at an important match or tournament.

Carlisle (Maryport).—Last week the Mayor of Carlisle publicly opened the National Telephone Company's trunk line between Carlisle and Maryport, which now completes telephonic connection between the county town and Whitehaven. From Maryport to Workington there are two trunk wires, and from the latter place to Whitehaven three. The new line from Carlisle has been anticipated for some time, but it was only within the last two months that its actual construction was undertaken, and finished under the superintendence of Mr. F. F. Bennett, Manager of the National Telephone Company in Cumberland, assisted by Mr. Jamieson, district manager, Carlisle. By its completion the whole of the West Cumberland system, including Maryport, Workington, Whitehaven, Cleator Moor, Frizington, Cockermouth, and Parton are brought into direct communication with the county town. The new line runs through Wigton, Aspatria, and on to Maryport. It is now three years since the telephone was introduced into the west of Cumberland, and since then between 400 and 500 miles of wire have been opened out. In the two years that the telephone has been in existence in Carlisle there has been 61 miles of wires erected. In the west of the county the subscribers number

about 250, and in Carlisle 57. The longest distance over which a person can speak on the wires is from Dalston to Egremont, both of which are loop wires, the distance being 54 miles. Subscribers now will be able to hold converse from their places of business with each other from either end of the county, and the outside public can also use the call offices and hold a conversation of three or four minutes duration on payment of a small fee. At the opening proceedings, Mr. Bennett, in reply to the toast of the Company, said that although at first they did not meet with success, recently the system had been increasing, although it was still far behind other parts of the kingdom. In ten towns taken from England, Scotland, and Ireland, which he named, the average all over was one subscriber to every 358 of the population. In Whitehaven they had one subscriber to every 285 of the population, Workington one to 421, Carlisle one to 600, Maryport one to 810, or taking the average of the four towns one to every 529 of the population. He claimed the telephone to be the cheapest mode extant for communication, and pointed out the advantages it offered for the detection of crime where police offices were connected by wire; and also what an immense boon it would be to the shipping interest on the Cumberland coast if the lighthouses, harbour offices, and coastguard stations were all joined together by wire.

Telegraphists' School of Science.—The twelfth annual distribution of prizes in connection with the above took place last Friday evening in the Postmaster-General's deputation-room. Considerable interest was manifested in the proceedings, which, in the unavoidable absence of the Postmaster-General, were presided over by Mr. C. H. Fischer (controller), who was supported by Mr. C. H. B. Patey, C.B. (secretary to the Post Office), Mr. W. H. Preece, F.R.S., and leading members of the department. For the City and Guilds Institute examination, the first prize in the United Kingdom for telegraphy, a silver medal and £5, was awarded to Mr. Frank Tandy, with a first-class honours certificate. Other successful students were:—First-class honours, Mr. J. Bailey and Mr. F. S. Parkinson; second-class honours, Mr. C. W. Winn. Ordinary certificates: First-class, Mr. W. J. Callow, Mr. A. G. Cardrey, Mr. A. E. Chapman, Mr. H. E. Cheel, Mr. C. H. Fleetwood, Mr. E. Harriss, and Mr. J. M'Pherson; second-class, Mr. H. Maguire and Mr. R. J. Talbot. For electrical instrument-making—honours certificate; second class, Mr. G. F. Mansbridge. For the Science and Art Department examination certificates: Mathematics (advanced) Mr. A. Brooker. Elementary—first class, Mr. F. Tandy; second class, Mr. J. Bailey, Mr. W. J. Callow, and Mr. H. Maguire. Magnetism and Electricity (advanced) first class and Queen's prizes, Mr. James Bailey and Mr. W. H. Cheel; advanced second, Mr. A. E. Chapman, Mr. C. H. Fleetwood, Mr. F. S. Parkinson, and Mr. C. W. Winn. The leading local prizes were to Mr. J. Bailey and Mr. F. S. Parkinson, for passing with first-class honours in telegraphy. First class, ordinary, or telegraphy—Mr. W. J. Callow, Mr. A. G. Cardrey, Mr. A. E. Chapman, Mr. H. A. Cheel, Mr. C. H. Fleetwood, Mr. E. Harriss, and Mr. J. McPherson; and Mr. F. Tandy for first-class in mathematics. The aggregate prizes were—the Controller's (first) to Mr. F. Tandy; and the Sub-Controller's (second) to Mr. James Bailey; these were accompanied by testimonials. The Engineering Superintendent's (third) was gained by Mr. W. J. Callow. Mr. Patey assured the meeting that the department would do all in its power to insure the continued prosperity of the classes, which had already been so marked a success. Mr. Preece impressed upon his hearers the practical advantages that would accrue from their following up their studies. A merited tribute of praise was accorded to Mr. W. Slingo, who is the teacher of the classes. A vote of thanks to the chairman and Mr. Preece concluded a very successful meeting.

Lectures on Electric Lighting.—We are glad to see the diffusion of more correct information about electric lighting among the masses by means of popular lectures. Mr. C. J. Snelus, F.R.S., has delivered such a lecture at Workington—that is in the midst of a district where trustworthy facts about electric lighting are calculated to bear good fruit, and lead to an increased use of the illuminant. We shall not follow Mr. Snelus through the whole of his lecture, but give the gist of his remarks on incandescent lighting. He said:—"Light may be produced by passing a current through a conductor which offers great resistance to its passage, as, for instance, a fine wire or thread of carbon. This is the basis of incandescent lighting. It was shown that when the current was passed through a fine steel wire the wire became red, then white hot, and finally melted. When passed through a thread of carbon the thread became white hot, and then burned. After many experiments, electricians found that the thread of carbon was the only successful medium for producing a light, but to prevent it burning away it is necessary to enclose it in a glass globe, from which the air is subsequently exhausted. In making glow or incandescent lamps, the carbon thread has first to be formed. Swan uses a cotton thread, which he steeps in dilute acid, then carbonised at a high heat embedded in charcoal. Edison uses thin strips of bamboo, which he carbonises in the same way. The carbon threads are then joined at each end to small platinum wires, formed into a loop, which is placed in a small glass bulb, and the platinum ends sealed into the glass by the blow pipe. The air is then exhausted from the bulb by a Sprengel pump, and the bulb sealed up by the blow pipe. So perfect is the vacuum in these lamps that only one particle per 4,000,000 is left in the bulb. As an illustration of the freedom of motion left to the remaining particles in an exhausted bulb, the lecturer passed the current from an induction coil through a Crookes vacuum tube, in which a light set of vanes, or windmill, was delicately poised. The few particles of air left in the bulb were repelled from the pole enclosed in the bulb, striking the vanes with great velocity, and causing the mill to spin, while the globe was filled with a beautiful purple light. To show the perfection of the vacuum in an ordinary lamp, the lecturer broke the point of one under some coloured water when the water immediately rushed in and filled the globe. The mode of fixing the lamps was then explained, and recent electric installations referred to. Mr. Snelus concluded by remarking that probably the finest installation of incandescence lighting was that at the Newcastle Exhibition, where lamps of 1,000 candle-power were shown, and large numbers of 500 and 800 candle-power, by Messrs. Clarke, Chapman, and Parsons, of Gateshead, under the name of the "Sunbeam" lamp. Two of such lamps of 200 candle power were handed round for examination, and the lecturer said that he considered these lamps constituted one of the greatest advances that had been made in electric lighting, and if they really were as durable as they were said to be, he thought they would rapidly displace the arc light, and immensely cheapen the cost of lighting up large spaces.

CONSTANT SPEED MOTORS.

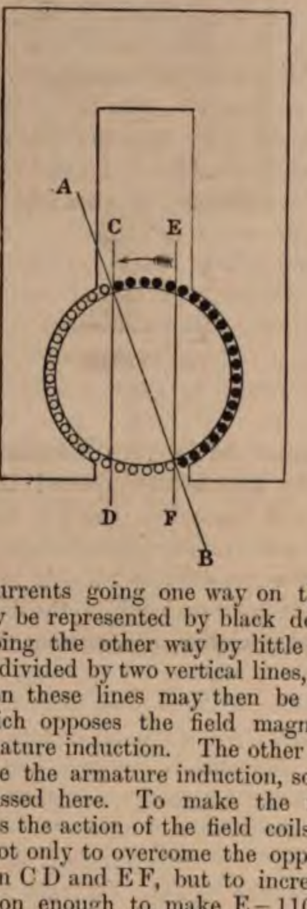
BY J. SWINBURNE.

Since the beginning of 1886, when Mr. Mordey first brought before the electrical world the theory that the principles of design are the same in a motor as in a dynamo, the truth of his views has been gradually acknowledged. In his article in the *Philosophical Magazine* Mr. Mordey makes some remarks, however, which are now known to be incorrect, and which he found to be so almost immediately the article was published. One of these was in reference to the supposed less efficiency of the motor, and another to the supposed analogy between constant E.M.F. dynamos and constant speed motors.

The idea is nearly universal now that a constant speed motor should be a sort of differentially wound machine. To get clear views, the action of a dynamo and motor must be considered, so that we may know what is required to make a constant speed motor.

Take the case of a separately excited dynamo which gives say 100 volts on the terminals with no current. Suppose, to fix the ideas, that the armature resistance is $\frac{1}{10}$ ohm, and the full current 100 amperes. At the full load of 100 amperes, suppose it is found that the machine gives 80 volts. As the armature resistance is $\frac{1}{10}$ ohm, 10 volts must be lost over it; so the armature E.M.F., which may be called E in accordance with Prof. Thompson's notation, is 90 volts.

The total armature induction is therefore lessened 10 per cent. The diagram has been used by the writer to explain this. Suppose A B is the diameter of commutation, then



the wires with currents going one way on the outside of the armature may be represented by black dots, and those with currents going the other way by little circles. The armature may be divided by two vertical lines, C D and E F. The wires between these lines may then be considered to form a coil which opposes the field magnet coils, thus lessening the armature induction. The other wires do not lessen or increase the armature induction, so their action need not be discussed here. To make the machine give 100 terminal volts the action of the field coils must be increased enough not only to overcome the opposition due to the wires between C D and E F, but to increase the total armature induction enough to make E = 110 volts. In a compound machine the series coils do this.

By induction, of course, magnetic induction is meant, not the induction of currents which is due to the change of magnetic induction through a closed conducting circuit.

Now, suppose the machine is wanted to run as a motor. We may either move the brushes to E and D and allow the machine to run the same way, or the machine may be run the opposite way, the brushes remaining at C and F, being merely turned, so that the commutator does not run against them and turn their ends up. In either case the armature wires between C D and E F oppose the induction. I have therefore for some time called this action the back induction, and the action of the other wires the cross induction. Now as the dynamo at full load when fully excited gives 110 armature volts and 100 amperes at the normal speed, which we may suppose to be 1,000 revolutions per minute, we must expect the machine as a motor to have 110 armature volts. As the armature resistance is $\frac{1}{10}$ ohm, the terminal E.M.F. will be 120 volts.

Now, suppose the load removed so that the current falls practically to zero. As the back induction causes a diminution of the total armature induction corresponding to 10 volts, the back E.M.F. will rise to 120 at the same speed, so that the machine will still run at 1,000 revolutions. If, instead of being separately excited, the machine is shunt-wound, of course, as the E.M.F. on it is constant, it still goes at the same speed. A shunt is, therefore, the proper machine to use as a constant speed motor. If the effect of the back induction is not equal to the loss by armature resistance, of course the speed is not constant. For instance, if the back induction lessened the total armature induction by an amount corresponding to 15 volts at full load, the machine would run slower at no load. Similarly if the effect of the back induction were small the motor would run faster at no load. Thus a machine which goes at constant speed with a high terminal E.M.F. and high speed will not go at constant low speed with a low terminal E.M.F. and the same field excitation, as the percentage loss by armature resistance is greater, while the percentage fall of armature E.M.F. by back induction is the same as before.

The back induction is, of course, dependent on the position of the brushes, and the position of the brushes is dependent on the design of the machine, so it is possible to design a machine which will, when simply shunt-wound, run at constant speed with varying load.

Though the writer has for a long time understood the theory of the action of the armature currents, he has unfortunately been unable to publish it for commercial reasons, as it is a matter of very great importance in large machines. As Messrs. Crompton and Co. have always been very generous to their electricians in this matter, however, one cannot complain. The discussion of the design of motors with the position of non-sparking, arranged so that they run at constant speed, must therefore be omitted, and the winding of a given machine alone discussed. Suppose the back induction small the field will be too strong at full load, so some backward turns of series coils are needed on the field-magnets to make up for their not being on the armature. These coils can never be so large as the series coils in a compound machine, because they only have to make up the difference of two effects instead of corresponding to their sum.

In a large high-speed motor the effect of the back induction is more important than that of the armature resistance, so that series coils are needed to oppose the back induction as in a compound-wound generator—that is, wound to assist the shunt coils.

It is then only in very small or slow speed machines that any backward main, to speak of, is needed; and the theory that a motor should be like a compound dynamo with its main reversed is wrong.

Differentially wound motors have another objection which seems to have been generally overlooked—namely, that they tend to start backwards. Of course, a motor with much back induction has the same tendency, if the brushes are put forward to begin with; but a motor should always be started with negative brush lead, so that the back induction is converted into forward induction. Of course it would spark if allowed to run like that. The writer had his attention drawn to the subject of shunt motors by Mr. Burton, who was one of Messrs. Crompton's pupils. In a discussion on the question of constant speed motors, he pointed out that as the object was to make a dynamo which would "compound down," and as a shunt dynamo compounded down, a shunt motor should run at approximately constant speed.

The electric motor has another property which is not known as well as it ought to be—namely, that it runs at more nearly constant speed than the dynamo which drives it. To take an imaginary simple case: suppose the field magnets and armature induction so small that the iron does not approach saturation; and suppose the effect of back induction and armature resistance neglected; if the external

E.M.F. falls to say 100 volts from 120, the back E.M.F. falls in the same proportion as the fields are weakened. The current then increases so that the power spent is the same as before, so that the speed does not vary. In practice a machine cannot be wound with its iron so slightly magnetised, as it would be unstable; moreover, the resistance of the armature would make the machine run slower to get the increased current. The back induction would increase as the current increased, and the brushes would need more lead as the field became weaker. On the whole the machine would run a little slower, but the speed would not fall anything like in proportion to the E.M.F. on the terminals. The same remarks apply to small differentially or large compound wound machines. The electric motor has, therefore, a property possessed by no others. Messrs. Crompton often use a shunt motor for driving dynamos when accurate tests are required and the engine speed varies.

As to the efficiency of motors the writer has already dealt with the subject to some extent elsewhere. There seems to be, however, a common impression that motors are not fully understood, and that there is a mysterious loss of power in them. Some imagine that both in dynamos and motors the armature resistance alters in some extraordinary way, others imagine that there is some source of back E.M.F. in the armature, due in some way to self-induction, which lessens the output either with or without loss of power. The writer can only say that he has never observed any loss of power by increase of resistance, or by back E.M.F., and cannot see how such things could take place.

The efficiency of the motor is higher than that of the dynamo, not lower. This is due, not to the machine losing less power as a motor, but to the way efficiencies are reckoned. The same anomaly arises with interest and discount.

Take as a simple case a series shunt motor taking 120 volts and 100 ampères, and going at 1,000 revolutions per minute. The series winding is taken for simplicity, the power lost in it being assumed as equal to that lost in the shunt if it had been shunt-wound. Suppose 10 volts lost in the armature, and 10 in the fields, and suppose 1,000 watts lost in conversion. These losses are very excessive, and are merely taken to make round numbers. As $e = 120$, and 20 volts are lost in internal resistance, the back E.M.F. $E = 100$. So the machine delivers 10,000 watts to its spindle, that is the product of 100 volts and 100 ampères. Of this, 1,000 watts is stray power, so 9,000 watts are given on the pulley. This is about $12\frac{1}{2}$ h.-p., but we need not go into h.-p's. As the motor takes $120 \times 100 = 12{,}000$ watts, its efficiency as a motor is 75 per cent.

Suppose the machine now run as a dynamo at the same speed and with the same current. The armature E.M.F. of course remains the same, $E = 100$, so $e = 80$. The output is therefore 80 volts and 100 amperes, or 8,000. The electrical power supplied to the circuit, including the armature and fields, is $100 \times 100 = 10{,}000$ watts. Taking the loss by stray power at 1,000 as before, the belt must supply 11,000 watts, to the pulley. The gross efficiency is therefore $\frac{8000}{11000}$, or 72·7 per cent.

As already mentioned, the losses of power are much smaller in practice. A well-designed large machine has an electrical efficiency of 95 per cent., and a gross efficiency of 93 per cent., or say that the efficiency of dynamo and motor together is nearly 86 per cent. With small machines it should amount to from 70 to 80 per cent., including both machines and leads over short distances. Over long distances the chief loss is of course in the leads.

TELEPHONES INSTEAD OF SPEAKING TUBES.

We have recently recorded that the "Equitable" and "New" Telephone Companies have opened out a new field of operations, in that they are installing their instruments in factories, warehouses, and hospitals in place of speaking tubes. The system adopted by the Equitable is herewith illustrated. The Swinton telephonic apparatus, Fig. 1, is employed. Here we see transmitter, receiver, call-bell, and switch-box. When not in use, the receiver hangs on a hook, and the call-bell is in circuit. On removal the bell is cut out, and the telephone transmitter and receiver put in circuit. The front of the switch box is fitted with plug holes, lettered with the names of the different stations comprised in the system. In connection with the terminals of the telephone is a flexible cord terminating in a small plug, which can readily be inserted in any one of the plug holes of the switch box.

For n telephones $n + 2$ wires are required, and these can be made up into a cable of very small diameter. For n speaking tube stations perfect communication can only be obtained with $\frac{n(n-1)}{2}$ separate tubes. Thus, to establish direct communication between, say, 12 stations, 14 wires, making a cable of about $\frac{1}{4}$in. in diameter, will do the work of 66 speaking tubes, occupying about 6ft. of wall space, and for larger numbers of stations the saving is still more marked.

Fig. 2 shows diagrammatically the telephone instruments, switch boxes, connections, and battery for an installation of six stations, A, B, C, D, E, F, distributed

FIG. 1.—Swinton Apparatus.

about a building. It will be seen that the left-hand plug hole of each switch box is marked with the letter that denotes the individual station to which this switch box belongs. Z and C are the wires connecting the various switch boxes to the zinc and carbon terminals of the battery, and 1, 2, 3, 4, 5, 6 are the six line wires that are necessary to connect the various switch boxes together. The terminals of the boxes are numbered, and all bearing the same number are connected to the same wire. When the telephones are not in use, the receivers are all hung up on their respective switch hooks, and the plugs are inserted in the left-hand plug holes of the several switch boxes. Thus the plug belonging to A is inserted in the hole marked A, that belonging to B in hole B, and so on, as shown in the illustration. Supposing A wishes to communicate with C, he has only to remove his receiver from its hook, remove his plug from the hole marked A of his switch box, and insert it in the hole marked C, to cause the call bell at C to ring, the ringing

of the bell being notified to A by a loud rattling noise in his telephone receiver, due to the current from the battery being rendered intermittent by the contact breaker of the bell at C. On C removing his receiver from its hook the noise ceases, and A knows that he can talk to C, and *vice versâ*. When the conversation is completed, A must replace his plug in the A hole of his switch box, so that other stations may be able to call him up if required. In a similar manner any one of A, B, C, D, E, F can call up and carry on a conversation with any other, and A and B can talk together while C and D are doing the same, or any other combination can be effected.

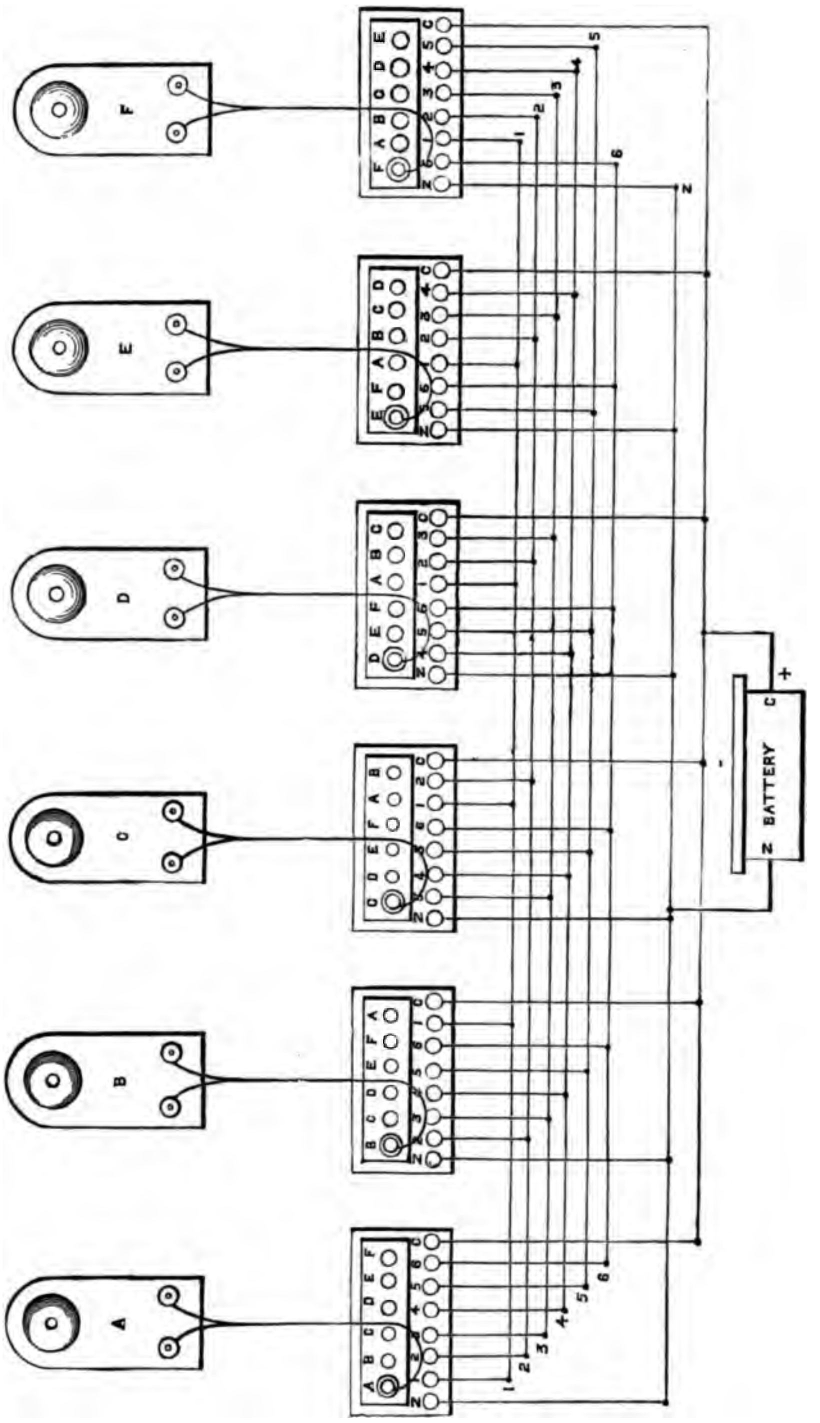


Fig. 2.—Connection for Six Stations.

The system is so arranged that if, say, B tries to call up A or C while the latter are conversing with one another, the absence of the rattling noise in his receiver on his attempting to call attention intimates to B that the line is engaged. This prevents interruptions of conversation and any possibility of confusion.

The above examples show the principles of the system when applied to six stations, but, of course, the switch boxes can be made with any number of plug holes for a system comprising any number of stations; and when it is convenient that only some of the stations should have the power of calling up all the others, only these particular stations need have switch boxes containing the full number of plug holes, and be connected with the full complement of wires, the cost of the installation being thereby considerably reduced.

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

(*Continued from page 31.*)

3. *Electro-motive Force; Difference of Potentials.*—Matter cannot be moved from rest without the application of force, and the assumption that electricity is an actual substance moving through conductors entails the farther conception of an electricity-moving or electro-motive force. The term *electro-motive force* is employed to convey the idea that potentiality of electric current has been established, but as force may be present producing mechanical stress without causing motion, so electro-motive force may exist, creating electric stress without producing a current. Though in a pipe leading down from a water tank and closed by a valve at its bottom end there is no current of water, the water-moving force is still present in the difference of water

pressure between the two ends of the pipe, and we have existing the potentiality of a current which can become an actuality when the valve is opened and the water allowed to pass. In similar manner when the armature of a magneto machine is spun round an electro-motive force is created at its brushes, the magnitude of this force being measured by the difference of electric pressure produced or by the potentiality of current established. As long as the brushes remain unconnected externally no current will flow, but when joined by a conductor a current will at once flow from one brush to the other. As the flow of water in a pipe is due to the difference of pressure urging it from a higher to a lower level, so the flow of electricity from one point to another is due to the difference of electric pressure, and proceeds from a higher to a lower level, or from a place where the pressure is greater to where it is less. The difference in electric pressure is termed *Difference of Potentials*, and to the agency which establishes a difference of potentials the name electro-motive force, written shortly E.M.F., has been given. The unit difference of potentials is the *Volt* equal to about ·7 of the difference of potentials which can be set up by a Clark's standard cell. Since this cell produces a difference of potentials of 1·44 volt we say 1·44 volt is its E.M.F., and by making up the cell always in the same way we can rely upon the E.M.F. always having the same value at a fixed temperature. It will be understood that the E.M.F. expressed in volts is the total difference of potentials which the source of electricity is capable of producing. By suitable instruments the difference of potentials between any two points in the circuit through which a current is flowing can be accurately measured. The point at greater potential is termed positive to the point at lower potential termed negative, the direction of the current in a circuit being always from the higher to the lower level, or from positive to negative.

4. *Resistance.*—The difference of potentials required to make a definite current flow between two points depends on the length, cross section, material, and temperature of the conductor. The difference of potentials required for example to send a current through a conductor of German silver will be about 13 times that required to send the current through an equal length and section of copper. There is determined between the difference of potentials and current in every circuit a ratio depending upon the kind of conductor employed and by this ratio is expressed the *Resistance* of the conductor. When the difference of potentials at the ends of a wire is doubled, the current flowing is also doubled, the resistance of the wire, so long as its physical conditions remain unchanged, being independent of the current flowing through it. The unit of resistance is termed the *Ohm*, and its value is such that through a conductor having a resistance of 1 ohm a current of 1 ampère will be caused to flow by a difference of potentials of 1 volt. A column of pure mercury 106 centimeters long by 1 square millimetre in section has at 0°C. a resistance of 1 ohm.

5. *Electrical Work.*—As in the case of water flowing in pipes we estimate the work done by the quantity of water passing multiplied into the difference of pressure, so in the case of electricity flowing in conductors the work done is calculated by the product of the quantity which passes and difference of potential. The coulomb has been defined as the unit of quantity, and the volt as the unit difference of potentials. The unit of electrical work is the product of these two, termed the *Joule*, and defined, therefore, as the work done by a coulomb in passing from one point to another, between which there is a difference of potential of one volt.

6. *Rate of Performing Work.*—A statement of the work done in joules conveys no impression of the rate at which electrical work is performed, since the term joule does not embrace the idea of time. Generally we do not require to know the number of joules performed in an hour or day but desire to know the rate at which work is being performed at the moment of observation. The unit rate of performing work is one joule per second, this rate being expressed by the term *Watt*. Thus, when we say that the rate of doing work in a circuit is 50 watts we mean that 50 joules of work are performed in every second if the rate is uniform. It must be clearly understood by the reader that a watt is not a *quantity* but simply a *rate*, and it will be seen that there exists between the joule and the watt, a relation very similar to that existing between the coulomb and the ampere. Yet about so simple a matter the greatest confusion has reigned in the past, and even now exists. We are continually hearing such meaningless expressions as "watts per second," and only recently was the watt defined by the British Association Committee as "the work done per second by the ampere passing between two points, between which the difference of potential is one volt." Here the joule and the watt are evidently blended in the direst confusion, though the definition was adopted on the motion of Mr. Preece, who is a great authority on the watt and all that pertains thereto. But the watt is no more work done than 50 miles per hour is a distance, or 10 per cent. a sum of money.

7. *Correlation of Electrical Units.*—The relations these units bear to each other will have been understood from the definitions given, but for their fuller comprehension they are here briefly summarised. If Q is the number of coulombs which passes in t seconds and C the current in amperes, then the relation between quantity and current, assuming that the flow is uniform, is given by the expression

$$C = \frac{Q}{t}$$

If V is the difference of potentials in volts and R the resistance in ohms, the relation between the difference of potentials, resistance and current is given by the expressions

$$C = \frac{V}{R}; \quad V = C\,R, \text{ and } R = \frac{V}{C}$$

these setting forth the conditions familiarly known as Ohm's law.

Calling J the work done in joules we have

$$J = Q\,V$$

while the rate of doing work, provided it is uniform, in joules per second or watts, W, is expressed by

$$W = \frac{Q\,V}{t}.$$

Since the current in amperes $= \frac{Q}{t}$ by simple substitution we can write

$$W = C\,V, \text{ also } = \frac{V^2}{R} \text{ and } = C^2\,R.$$

(To be continued.)

COMPOUND STEAM TURBINES.*

We shall begin by describing water turbines and some of their performances, together with the necessary conditions for economy in motors of this class. We shall then describe the compound steam turbine, and draw a parallel between it and the water turbine, showing by the help of the latter that the conditions for high economy are fulfilled in the compound steam turbine. We shall then give figures to show what the theoretical economy of the compound steam turbine should be, and then deal with the dynamo and its combination with the steam turbine. Water turbines have been for many years in extensive use in Europe and America, and have, after many experiments, been brought to a very high degree of perfection, as is shown by the numerous tests that have been made to ascertain their actual efficiency. Perhaps the most carefully arranged and the most exhausive of these experiments are those made by Mr. James B. Francis on the Tremont turbine at Lowell, Massachusetts. The result showed that the horse-power indicated on the dynamometer attached to the shaft amounted in some cases to 79·3 per cent. of the total power of the water, whilst those made on another turbine of still more improved design gave an efficiency of 88 per cent. The theory of the turbine has been thoroughly dealt with and understood, and theoretical reasoning leads also to the conclusion that such a high efficiency in a turbine is quite possible provided that certain rules are adhered to in the design, and provided also that certain essential conditions as to the flow of water

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders by the Hon. C. A. Parsons.

are provided for. All water turbines consist essentially of a set of fixed vanes, called guide blades, and a set of moving vanes called the wheel; the former guide the water towards the direction of motion of the latter. The important conditions for economical working being that the shape of the blades and the velocity of the wheel shall be so arranged that there shall be no shock or sudden change of the velocity of the water in passing from the guide blades to the moving blades, and also that as the velocity or energy of the water on leaving the wheel is lost it shall be reduced to the utmost extent by the formation of the blades. This leads us to inquire what has been found to be the best velocity of wheel to meet these conditions. In Mr. J. B. Francis' experiments, we find—

Experiment.	Per cent. of Velocity of wheel, of Velocity due to head.	Efficiency.
42	30	67
41	39	72
36	50	78
30	63	79·3

We have here then the speed which gives the maximum efficiency, and a measure of the diminution of efficiency corresponding to a reduced speed. The essential conditions for high efficiency are, as we have said, absence of shock and low residual velocity. These conditions, in the case of the water turbine, can be better obtained in the types called the outward or inward flow than in the parallel flow, for the large volume of water to be dealt with necessitates long blades of double curvature for the last-mentioned type; these are objectionable, while it is more difficult to minimise the residual velocity of the water leaving the wheel. Principally these reasons have led to the more general adoption of the outward or inward flow types than of the parallel flow. After careful consideration, however, the parallel flow type seemed more suitable to the compound steam turbine, and has been accordingly adopted. Fig. 5 shows the arrangement of ninety complete turbines, forty-five lying on each side of the central steam inlet. The guide blades, R, are cut on the internal periphery of brass rings, which are afterwards cut in halves and held in the top and bottom halves of the cylinder by feathers; the moving blades, S, are cut on the periphery of brass rings, which are afterwards threaded and feathered on to the steel shaft, and retained there by the end rings, which form nuts screwed on to the spindle. The whole of this spindle, with its rings, rotate together in bearings (shown in enlarged section, Fig. 2). Steam entering at the pipe, O, flows all round the spindle and passes along right and left, first through the guide blades, R, by which it is thrown on to the moving blades, S, then back on to the next guide blades, and so on through the whole series on each hand, and escapes by the passages, P, at each end of the cylinder connected to the exhaust pipe at the back of cylinder. The bearings, Fig. 2, consist of a brass bush, on which is threaded an arrangement of washers, each successive washer alternately fitting to the bush and the block, while being alternately $\frac{1}{32}$nd smaller than the block outside, and $\frac{1}{32}$nd larger than the bush in the hole. One broad washer at the end holds the bearings central. These washers are pressed together by a spiral spring, N, and nut; and, by friction against each other, steady or damp any vibration in the spindle that may be set up by want of balance or other causes at the high rate of speed that is necessary for economical working. The bearings are oiled by a small screw propeller, I, attached to the shaft. The oil in the drain-pipes, D and F, and the oil tank, D, lies at a lower level than the screw; but the suction of the fan, K, raises it up into the stand pipe, H, over and around the screw, which grips it, and circulates it along the pipes to the bearings. The course of the oil is as follows: The oil is forced by the propeller, I, and oils the bearing, A (Fig. 1), the greater part passes along the pipe E to the end bearing C, some, after oiling the bearing C, drains back by the pipe F to the reservoir D, the remaining oil passes along through the armature spindle, oils the bearings, B, and drains into the reservoir, D, from which the oil is again drawn along the pipe, G, into the stand pipe, H, by the suction of the fan, K. The suction of the fan is also communicated to the diaphragm, L, and forms, with it and the spring, M, the principal part of the governor which actuates the throttle valve, V. Fig. 3 is the electrical control governor, which will be further described in connection with the dynamo. It acts directly upon the controlling diaphragm, L, by admitting or exhausting a quantity of air, and thus exercises a controlling influence upon it. For small differences of pressure, the velocity of air or steam passing through orifices or short tubes is given by the same formula as that for water. The heads of pressure have to be calculated in each case in terms of the respective fluids, and for small differences of pressure the velocity of efflux is the same for the same head in all cases. This has been recognized as a fundamental principle; it has also been verified in some of the cases we are going to consider by actual measurements. We now proceed to consider the action and condition of the steam as it passes through the successive turbines; but, before doing so, it will be necessary to go into some calculation in order to form a correct basis to start from. The velocity of efflux of steam flowing from a vessel at 15·6lb. per square inch absolute pressure through an orifice into one at 15lb. absolute pressure is 366ft. per second, the drop of pressure of ·6lb. corresponding to a diminution of volume of 4 per cent. in the opposite direction. We must now suppose that the turbines are so proportioned and the blades so diminished in size that each one nearer the steam inlet O has 4 per cent. less blade area or capacity than the preceding one all the way from each of the exhaust ends up to the centre. If we work this out we find that after forty-five turbines the pressure will be about 69lb. above the pressure at the inlet. The steam will have followed some curve of temperature and volume very near the adiabatic; but on the isothermal side of it, the velocity of flow will be slightly greater near the inlet, in consequence of the increased temperature. The steam enters from the steam pipe at 69lb. pressure, it passes through the first turbine, consisting of a ring of guide blades and then a ring of moving blades, and falls 2·65lb. in pressure; the velocity due to this fall in pressure is 386ft. per second, its volume increases by 3·85 per cent. of its original volume, it passes the second turbine, falls 2·55lbs., and again increases its volume in the same ratio, and so on till it reaches the last turbine, where its pressure is 15·6lb. before entering, and 15·0lb. on leaving it to flow into the exhaust pipe. The velocity due to the last drop is 366ft. per second. The steam has therefore nearly the same velocity of flow for all the turbines; in other words, the error in assuming the velocity due to the head to be 376ft. per second throughout does not exceed 3 per cent. The velocity of the wheels at 9,200 revolutions per minute is 150ft. per second, or 39·9 per cent. of the mean velocity due to the head throughout the turbines. On comparing this ratio of velocity of wheel to velocity of flow with that of the Tremont water turbine, we find a corresponding efficiency of a little over 72 per cent. Hence in the compound turbine we are describing, the velocity of the blades is sufficient to secure a very high return of useful effect. We may therefore assume that if the blades be equally well shaped in the steam turbine as in the water turbine, and that the clearances be kept small and the steam be dry, then each turbine of the set will give an efficiency of at least 72·5 per cent. We say at least, because as each turbine discharges without check into the next, the residual energy after leaving the moving blades is not lost, as it is in the case of the water turbine we are considering (it amounts to from 3 to 5 per cent. of the energy), but continues into the next guide blades, and is wholly utilised there in assisting the flow. This unchecked flow from one turbine to another is a great advantage of the parallel flow type over other types where a number of turbines are compounded. It also minimises the skin friction, as nearly the whole of the moving part is covered with blades, and there is consequently no appreciable loss due to this cause. As each turbine of the set gives 72·5 per cent. efficiency, it follows that as the steam at all points expands gradually without shock, that the motor as a whole will give an efficiency of at least 72 per cent. of the total mechanical energy of the steam, or, in other words, over 72 per cent. of the power derived from using the steam in a perfect engine, without losses due to condensation, clearances, or friction, and such like. A perfect engine working with 90lb. boiler pressure, and exhausting into the atmosphere,

would consume 20·5lb. of steam per hour for each horse power; a motor giving 70 per cent. efficiency would therefore require 29·20lb. of steam per horse power per hour. We have now gone sufficiently into the question to show clearly that in the compound steam turbine we have a motor whose theoretical efficiency is very high indeed. The fact that at each turbine of the set the temperature is constant, enables us to predict that there can only be a very minute loss arising from condensation. This has been conclusively verified by experiments with superheated steam, coupled also with the fact that "for small differences of pressure gases and vapours act like liquids in flowing through orifices and tubes, in virtue of the small differences of pressure, and that the velocity of flow is regulated by the fundamental formula $v = 8\sqrt{h}$." These three facts draw the analogy between the water turbine and the compound steam turbine for efficient working as close as it is possible to draw anything, and it does not seem too much to expect, in the larger sizes at any rate, an equally good efficiency.

The dynamo which forms the other portion of the electric generator, Fig. 1, is coupled to the motor spindle by a square tube coupling fitted on the square spindle ends. The armature is of the drum type, the body is built up of thin iron discs threaded on to the spindle and insulated from each other by tracing paper. This iron body is turned up, and grooves milled out to receive the conducting wires. For pressures of 60 to 80 volts, there are fifteen convolutions of wire, or thirty grooves. The wire starting at *b*, Fig. 4, is led a quarter of a turn spirally, *c*, round the cylindrical portion, *a*; then passing along a groove longitudinally is again led a quarter turn spirally, *d*, round the cylindrical portion, *a*; then through the end washer and back similarly a quarter turn, *e*; then led along the diametrically opposite groove; and, lastly, a little over a quarter turn, *f*, back to *g*, where it is coupled to the next convolution. The commutator is formed of rings of sections; each section is formed of short lengths; each length is dovetailed and interlocked between conical steel rings; the whole is insulated with asbestos, and when screwed up by the end nut forms with the steel bush a compact whole. There are fifteen sections in the commutator, and each coupling is connected to a section. The whole armature is bound externally, from end to end, with brass or pianoforte steel wire. The magnets are of soft cast iron and of the horseshoe type; they are shunt wound only. On the top of the magnet yoke is the electrical control governor, Fig. 3. It consists of one moving spindle on which are keyed a small soft iron bar, and also a double finger T. There is also a spiral spring, X, attached at one end to the spindle, and at the other to an adjustable top head and clamping nut, Y. The double finger, T, covers or opens a hole in the face, U, communicating to the pipe, W, with the diaphragm, L. The action of the magnet yoke is to attract the needle towards the poles of the magnet, while by turning the head the spiral spring, X, is brought into tension to resist and balance this force, and can be set and adjusted to any degree of tension. The double finger, T, turns with the needle, and by more or less covering the small air inlet hole, U, it regulates the access of air to the regulating diaphragm, L. The second finger is for safety in case the brushes get thrown off, or the magnet circuit be broken, in which case the machine would otherwise gain a considerable increase of speed before the diaphragm would act. In these cases, however, the needle ceases to be attracted, falls back, and the safety finger closes the air inlet hole. There is no resistance to the free movement of this regulator. A fraction of a volt increase or decrease of potential produces a considerable movement of the finger, sufficient to govern the steam pressure, and in ordinary work it is found possible to maintain the potential within 1 volt of the standard at all loads within the capacity of the machine, excepting only a slight momentary variation when a large portion of the load is switched on or off.

The resistance of the armature from brush to brush is only ·0032 ohm, the resistance of the field-magnets is 17·7 ohms, while the normal output of the dynamo is 200 amperes at 80 volts. This, excluding other losses, gives an efficiency of 97 per cent. The other losses are due to eddy currents throughout the armature, magnetic retardation, and bearing friction. They have been carefully measured. By separately exciting the field-magnets from another dynamo, and observing the increased steam pressure required to maintain the speed constant, the corresponding power was afterwards calculated in watts. The commercial efficiency of this dynamo, after allowing for all losses, is a little over 90 per cent. In the larger sizes it rises to 94 per cent. Assuming the compound steam turbine to give a return of 70 per cent. of the total mechanical energy of the steam, and the dynamos to convert 90 per cent. of this into electrical output, gives a resulting efficiency of 63 per cent. As steam at 90lb. pressure above the atmosphere will, with a perfect non-condensing engine, give a horse-power for every 20·5lb. of steam consumed per hour, it follows that an electrical generator of 63 per cent. efficiency will consume 32·5lb. of steam for every electrical horse-power per hour. Again, with steam at 150lb. pressure above the atmosphere, a generator of the same efficiency would consume only 22·2lb. of steam per electrical horse-power per hour.

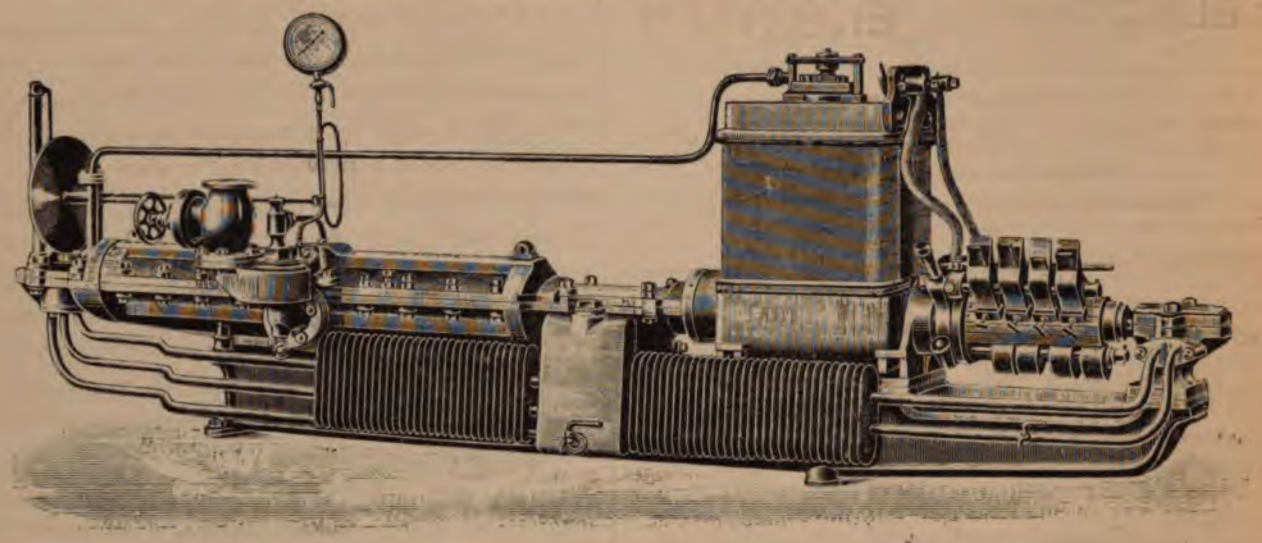
The results we have so far actually obtained are a consumption of 52lb. per hour of steam for each electrical horse power with a steam pressure of 90lb. above the atmosphere. We, however, expect shortly to obtain results more nearly coinciding with those very high economies that theory has led us to believe possible with this system. In the larger sizes, so far as we have yet gone, we have invariably found increased economy, as in them the clearances are proportionately less, and it is easier to arrange the distribution of steam. Exceptionally low steam consumption is not the only essential attribute of an electric generator—there are other considerations, in most cases of more importance; these are steadiness of the current produced, freedom from accident, and simplicity, small first cost and cost of maintenance, little attention required, smallness of size and weight for a given output, and an almost insignificant consumption of oil.

To illustrate this, we will take the installation of the Phœnix Mills, Newcastle-on-Tyne, which has been running on the average of eleven hours daily for the last two years. Out of the original 159 Edison-Swan 16 c.p. lamps, 65 are still in good condition, having run 6,500 hours at about standard brightness. Now, if the lamps had only lasted 1,000 hours on the average, the cost of lamps renewed would have amounted to about double the year's cost of fuel as at present consumed.

At the Newcastle-on-Tyne Industrial Exhibition thirteen of these turbo-electric generators lighted the whole of the courts, giving a total of about 280 electrical h.-p. During the whole run of the Exhibition the only noticeable accident which occurred to the installation was due to the blowing out of the packing in a branch steam pipe connecting another engine to the main steam pipe supplying the generators; but as there was no stop valve in this branch pipe the engineer in charge deemed it prudent to shut off steam at the boilers, thus stopping all the generators lighting the four courts for about three-quarters of an hour. This, however, was an accident quite external to the generator, and, as it happened, external to the main steam pipe supplying them. We believe that it was only on three occasions during the run of the Exhibition that a small group of lamps were extinguished for the few seconds necessary to enable a spare generator to be started and switched on to them. The seventeen generators were in two groups; had they been placed in one group the results showed that on all occasions one spare generator would have been sufficient to keep every lamp alight.

In regard to simplicity and cost of maintenance, we may say that in a 30 h.-p. generator there is no part that three men cannot lift, and that every part is immediately accessible. After two years' working, of ten hours daily, we have found the wear very small indeed, in some cases almost inappreciable, the blades or vanes show no signs whatever of any cutting action of the steam. The commutators in the larger generators have generally withstood this amount of wear, while in some cases where they have been carefully attended they have suffered very little wear indeed. We have at the present time some important experiments being carried out in regard to the generators. *(For illustrations see next page.)*

PARSON'S TURBO-GENERATOR.



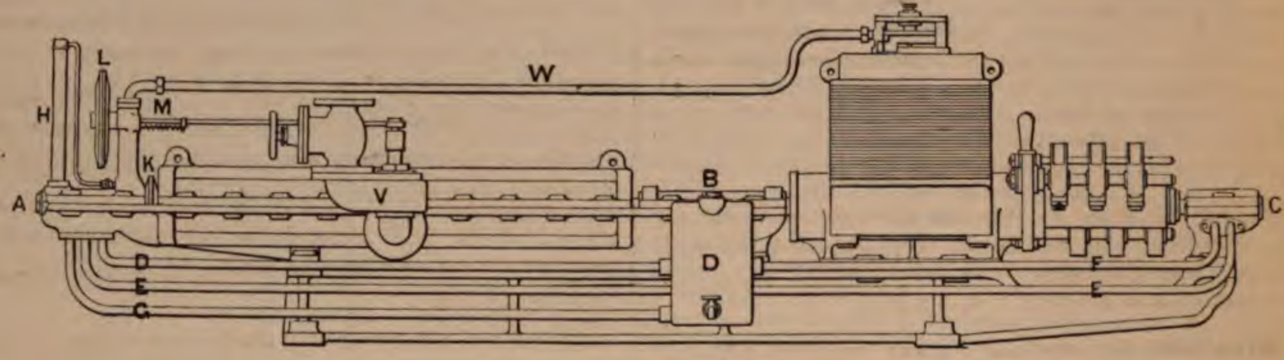


Fig. 1.

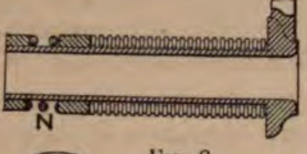


Fig. 2.

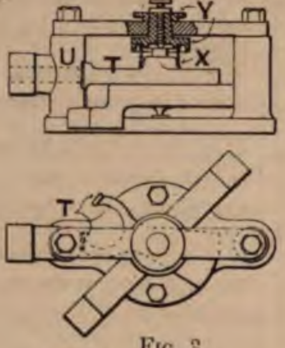


Fig. 3.

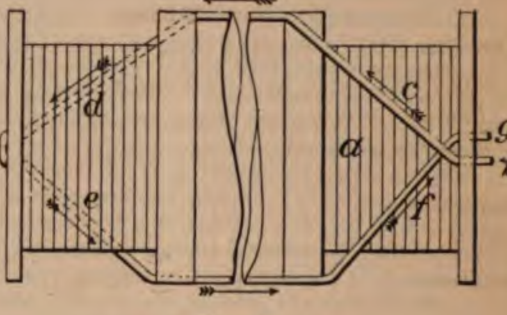


Fig. 4.

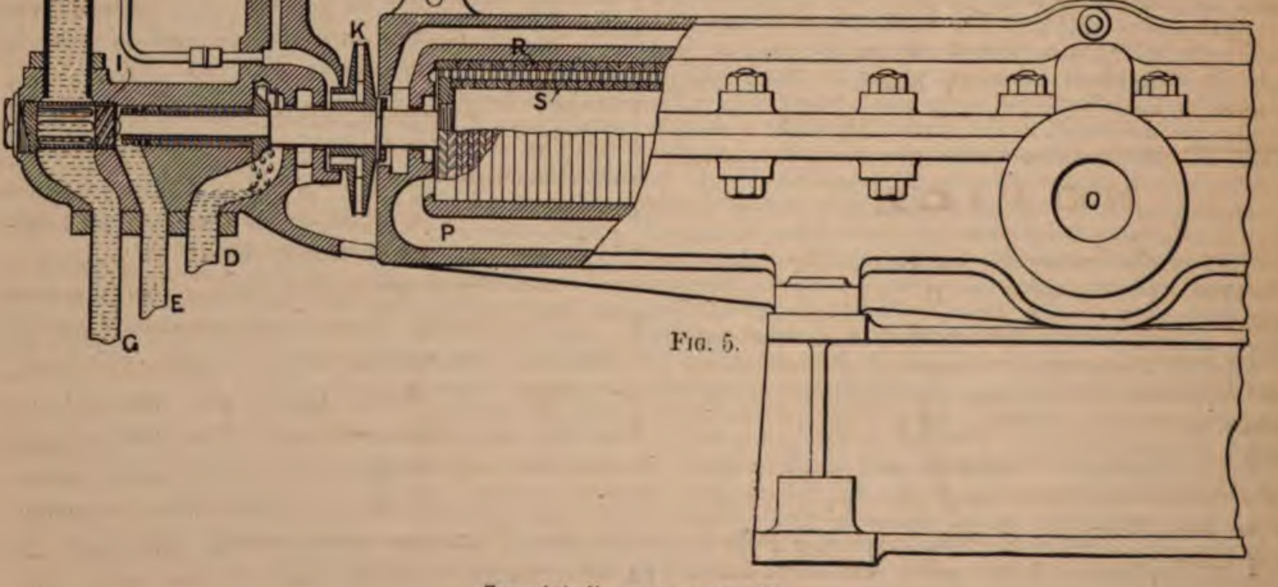


Fig. 5.

For details see page 57.

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NOTICE.

With our issue of January 6 a fine steel engraved Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers (Institution of Electrical Engineers), was issued. In future numbers we shall give a series of Portraits of other eminent Electricians of this century, including Portraits of Past Presidents of the Society of Telegraph Engineers. The next Portrait will be that of* WOLLASTON, *who flourished at the end of the last and the beginning of this century, and whose name has been immortalised by being applied to a particular form of battery designed by him. This will be followed by Portraits of* PROF. D. E. HUGHES, F.R.S., *and* SIR H. DAVY.

PARIS, 1889.

It is a long time ahead that the Paris International Exhibition will be opened, but if the English electrical engineering industry is to be adequately represented, preparations must be commenced at an early period We do not intend to weary our readers with the nonsense about exhibitions being necessary to the welfare of nations, of their having an educational value, and conducing to the peace of the universe. From our point of view all exhibitions must be considered from the stand-point—do they pay? will business be increased or decreased thereby? These questions appeal not only to individual exhibitors but to those engaged in the industry collectively.

At the Paris Exhibition in 1878 the great development of electricity—electric lighting—had hardly commenced. It was in fact the exhibits at that exhibition, and the stir made by the lighting of some of the streets around the Opera House by Paul Jablochkoff, that attention was directed to the possibilities of such lighting. A few years later, in 1881, showed the new departure in an exhibition solely devoted to its interests. Since then progress has been made by leaps and bounds, not only in the arc lighting but in the production of the incandescent light, a light far more suitable for interiors than the arc light.

A few facts connected with these early stages of the industry must never be forgotten. First, hardly any scientific or business man was prepared for the surprise of Jablochkoff in 1878; and secondly, those who should have known better were completely surprised in 1881 at the progress made in three short years. Between 1881 and 1889 is a space of eight years, and if Paris has already given us two surprises, will it not be best to prepare for a third? It is all very well to imagine that exhibitions are "played out," but we dare not act upon such vain imaginings. At this somewhat critical period of the industry, England must be well represented, unless indeed she is willing and eager to hand over to Continental rivals the position she has gained. It is well known that at present the Continental demand for our manufactures is good, and in order to retain this market it behoves us to show that we are well ahead of all competitors. Unfortunately, adequate representation means the outlay of large sums of money, and at this time profits are small, so that it is difficult for heads of firms or directors of companies to decide upon the outlay. Impecuniosity will not be paraded if there is a sufficient prospect of increased business as a return for the outlay. Other reasons are urged for not exhibiting. It shows competitors our designs, our work, our dodges. It allows them to copy, and so bring their wares up to a line with ours. The time has gone past for these arguments to have much weight. Exhibitions are a part and parcel of the world's commercial enterprise. Customers and probable customers are brought together from the ends of the earth. The warehouse is transformed from a back street, a three-

floor storey, or a country town, to—for the time being—the "hub of the universe." Business men as a rule have to sell their productions now-a-days, not wait for customers to seek them out. Trade means going to the busy marts, to the highways and centres of industry, and by steady perseverance proving that the buyer must buy, and that he cannot buy better than of the seller.

Altogether, the consideration of the "pros" and "cons" must, we imagine; cause a decision in favour of the "pros." Taking first the "cons." The principal are "expense," "making every competitor acquainted with our work," "uncertainty of return," "satisfaction with what we are now doing, and no desire to increase output," "trouble and worry." The "pros" may be given as "probable increase of business sufficient to cover all expenses and put something to the credit of profit," "the showing of would be customers or old customers that the exhibitors' productions are equal, if not superior to any other in the market," "the making known the name and products of the firm, first from the number of visitors, secondly from the descriptions written for or by the press." If figures could be obtained they would show that business done was strictly in proportion to the number of people making enquiries, or in proportion to the number of people knowing the firm's productions. Once recognise that the outcome of exhibitions must be business, and that "gold medals" and other prizes are sought after as having a certain value to assist the sales, and all will be plain sailing. We deliberately, and after due consideration, have determined to treat these exhibitions from the purely business point of view. It is our duty and the duty of the technical press generally to do its utmost to describe and illustrate examples of industrial applications of the special branch it treats. The press is only a part of the business machine with certain and fairly well-defined duties to perform; one of these duties being an extremely sensitive regard in season and out of season to further the business interests of those engaged in the industry. The business house that attempts to ignore the value of technical journals as a means to promote greater activity in all branches of the industry, will in these times of fierce competition soon find itself relegated to the back-ground.

This brings us finally to the suggestion that the Institution of Electrical Engineers should take up the work of nominating a suitable committee, that this committee should be as representative as possible, and that from first to last the committee should consider the welfare of the industry. In France, in Germany, and in Austria it is customary to have representatives of the press upon committees, but hitherto in England these gentlemen have been thought better off than on committees. This example of other countries might with advantage be followed, as it would probably lead to greater interest being taken to completely represent the industry, and to describe the exhibits. The more systematic and exhaustive such description the better for exhibitors and the public.

APPLIED SCIENCE IN THE DAILY PRESS.

Amongst the "infinite possibilities" of art, if not of nature, is the comic element in scientific journalism. Were we inclined to develop this, we might find ample opportunities in the utterances of the daily press whenever it takes up a question in relation to the application of scientific principles and discoveries. Amusement might be extracted from an enquiry into the perversion of the eternal fitness of things through which the writers have been called upon to treat such questions, or into the Rip Van Winkle condition of torpid non-observance in which they must have existed for years before they favour the public with their anachronous lucubrations.

The immediate occasion of our present observations is a recent article in the *Morning Post* in which, after a playful review of the negotiations between the City Streets Committee and "a Company engaged in spreading the new light," and the ventilation of a fear, on the part of "many quiet and law-abiding folk, that there must be something uncanny in the prospect of a time when, so far as light is concerned, it will be always noon in the City," the writer proceeds to enlighten the public with his own views anent the new light in question. He points out that "it"—the electric light—"is painfully intangible and mysterious; it cannot be seen or smelt like gas; though it is but fair to admit, on the other hand, that it does not testify its existence by violent explosion." One might imagine that a light which, though "almost too brilliant while it lasts," cannot nevertheless be either "seen or smelt," would be sufficiently condemned; but, like the naval officer who was anxious to supplement the fact that he had no powder with forty-nine other reasons for not having fired a salute, the writer proceeds to point out other objections to the illuminant. It appears that "it"—the electric light—"cannot be measured out and distributed in convenient quantities for household consumption, as gas can." The supply—whatever may be the views and conclusions of T. A. Edison and J. T. Sprague, *cum multis aliis*—must be in inconvenient quantities, presumably either too great or too small. Still, there is hope; if not for the present at least for the future. "The system of accumulators opens out a wide prospect. It may be that, in years to come, the prudent householder will store up against the winter his stock of electric accumulators, just as the Irish peasant builds up his stack of turf." Shades of Douglas Jerrold and Tom Hood! is there anything more funny, outside of the domain of scientific applications, than the picture of the prudent householder storing up his accumulators "just as the Irish peasant builds up his stack of turf"? Certainly there is something "uncanny" and "mysterious" about the accumulator referred to by the

Morning Post. "Stock of accumulators" is good, very good; but supposing that, as might happen with the turf, it became exhausted before the winter was out. The idea is a painful one; but fortunately we may find relief and consolation in the final conclusion of the *Morning Post* writer, viz.:—that, after all, the Electric Light "is so manifestly superior to gas as an illuminant that its ultimate success is assured."

The good things of the *Morning Post*, however, pale their ineffectual fires before a subsequent criticism of the *Daily News* upon Electrical Industry. It would occupy too much of our space to consider the *Daily News* article; but if readers conversant with the Electric Lighting industry are interested in exposing ignorance, they may well take in hand the article referred to which appeared on January 19th.

LITERATURE.

A course of Lectures on Electricity, delivered before the Society of Arts by GEORGE FORBES, M.A., F.R.S. (L. and E.), &c. [London: Longmans, Green and Co.]

It is generally understood that a little leaven leaveneth the whole lump, and the same may apply to scientific books, a few good ones will perhaps pave the way for the whole to be good ones, though the time occupied in educating purchasers will cause the grist in the authors mill to be very meagre. Prof. Forbes has in this book given information relating to electrical matters which the student will not have to unlearn when he leaves the student for practical life. The reader has here a good solid foundation, upon which he may build without danger to the superstructure. It is only during the last few years that books of this kind have been issued. Most of these, however, which we could recommend have been written more for use in schools than for the general reader. Prof. Forbes' book has been written from quite a different point of view. The basis of the work was the shorthand notes taken during a course of Cantor lectures before the Society of Arts. These notes have been elaborated and altered to their present form. The scope of the work will be gleaned from the following sentence:—"The lectures were primarily intended for an intelligent audience, ignorant of electrical science, but anxious to obtain sufficient knowledge of the subject to be able to follow the progress now made in the science"—*vide* Preface. The number of people who could listen to the lectures was limited, the number they appealed to is very large, and we must acknowledge that the design of the author has been well carried out. The information given is just that required by an intelligent reader—not descending to the frivolous, nor soaring into the transcendental, but clearly placing the broad, fundamental facts of the science within the grasp of the reader.

The first lecture treats of potential and electromotive force, the illustrations and experiments being mostly taken from the domain of statical electricity. It may perhaps be well here for us to illustrate the author's method and style by the following extract (p. 13):—"When those powerful generators of electricity called dynamo machines are at work we often speak of the difference of potential at the terminals or at the brushes. The expression will be so often used in describing electrical phenomena that I will now say a few words about it. It is a comparatively new expression in scientific language, but one of great importance. We know that the force of gravity gives velocity to a falling body, and the body acquires energy of motion—*kinetic* energy it has been called. But when a body is raised from the floor to the table it acquires energy of position, not of motion, because it has the power of falling to the floor, and so doing a certain amount of mechanical work. How are we to define the energy which exists in a ball when placed on a table? It has a potency of doing work. It has what Rankine called potential energy, and the word expresses very well what we mean. Suppose a ball be thrown up in the air. At starting it has kinetic energy, energy of motion, which gradually diminishes and disappears, giving place to energy of position at the top of the ball's flight when the ball has no motion. The great principle of the conservation of energy tells us that at each part of the ball's flight the sum of these two energies remains the same (neglecting the slight dissipation of energy by friction with the air). You understand then what we mean by potential energy. The difference of gravity potential between the floor and the table is measured by the energy given off by a unit mass falling from the table to the floor, or by the work that is done in raising a unit mass from the floor to the table.

"If now I have a piece of glass positively, and a piece of silk negatively, electrified, some work must be done in moving a body with a unit charge of positive electrification from the silk to the glass. This measures the difference of electric potential between the glass and silk."

It will be sufficient if we now indicate the contents of the succeeding chapters. The second lecture deals with electric current and resistance, the next with magnetism, the next with electro-magnetism, the fifth being on electro-magnetic induction, and the work concluding with a lecture delivered at Philadelphia on dynamo-electric machinery.

It will be seen that the ground traversed is such as to prepare the reader for the practical work of electric engineering, and especially in those branches which have been so rapidly developed during the past three years. It is hardly necessary to say that the work is well illustrated and printed.

EDISON AND SWAN COMPANY'S MINER'S LAMP.

The lamp (Fig. 1), which was referred to in the article by Mr. Swan in a previous issue, consists of a storage battery

FIG. 1.

FIG. 2.

of four cells (Fig. 2), enclosed in a strong teak box turned out of the solid and strengthened with metal bands (B); and a small incandescent lamp mounted on the side of the

FIG. 3.

case, protected by a strong glass cover (C). The case is fitted with a hinged lid secured by a cross bar fastened with a safety-nut (F), and having a swivel-handle (D). The

full size of the lamp is 7in. by 4¼in., and the weight of the whole ready for use is about 6lbs. 13oz. The lamp is opened by unscrewing the safety-nut (F) by means of the key (Fig. 5), and lifting the lid which turns on the hinge (G). Then by means of the small key (Fig. 4) the battery can be withdrawn. The battery of four cells or accumulators, joined in series, has the terminals brought down the sides

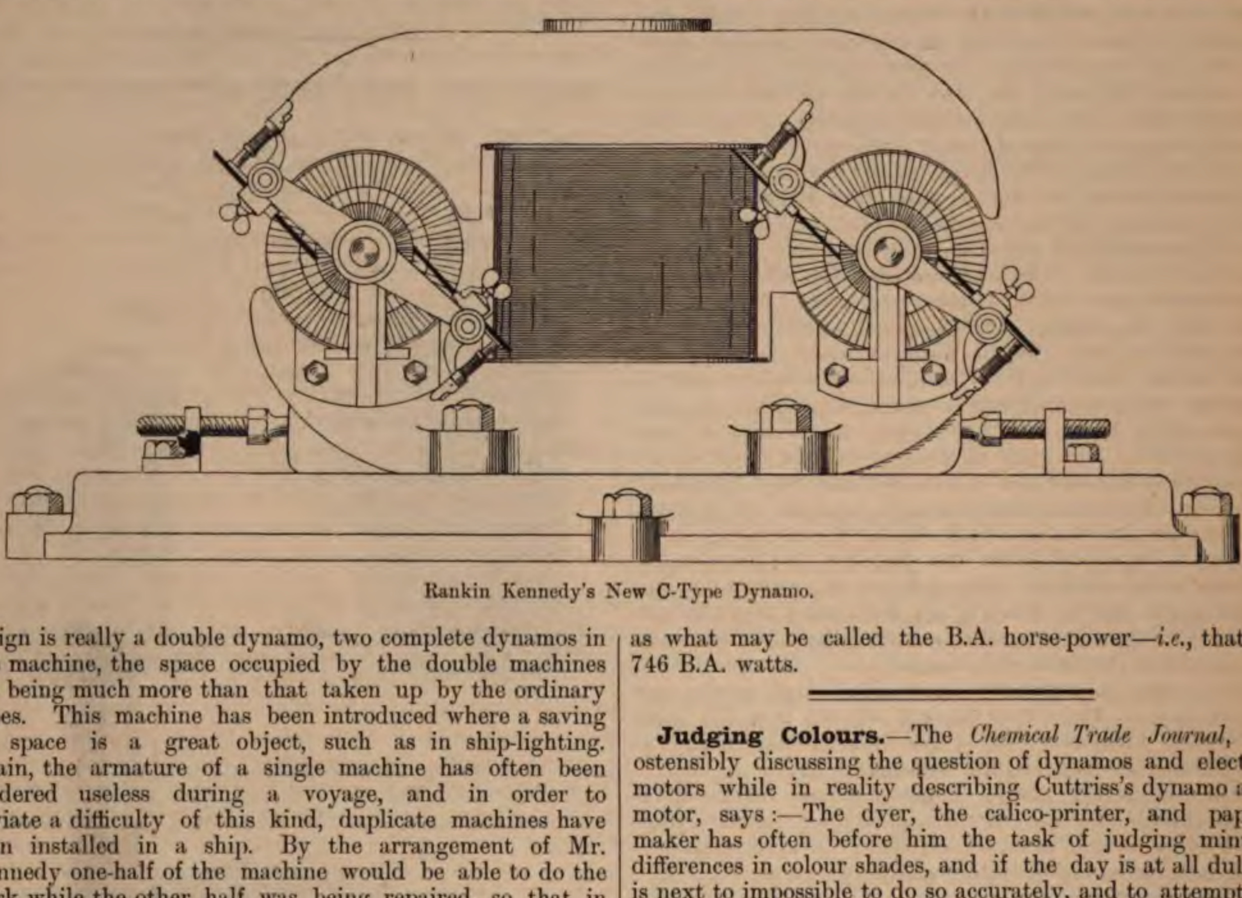

Fig. 4.


Fig. 5.

of the battery (as shown at H) in the form of two contact plates, which, when the battery is put into the case, come in contact with two corresponding plates in the case, and so convey the current from the battery to the small incandescent lamp. Fig. 3 shows the frame in which the battery stands while being charged with current from the dynamo. The lamp may also be had with fire-damp indicator attached. This indicator is a modification of Mr. Lievings.

KENNEDY'S DYNAMOS.

Another type of dynamo designed and introduced by Mr. Kennedy not referred to in our article last week is what he terms his C type, and is more especially designed for ship lighting. As will be seen from the illustration, this


Rankin Kennedy's New C-Type Dynamo.

design is really a double dynamo, two complete dynamos in one machine, the space occupied by the double machines not being much more than that taken up by the ordinary types. This machine has been introduced where a saving of space is a great object, such as in ship-lighting. Again, the armature of a single machine has often been rendered useless during a voyage, and in order to obviate a difficulty of this kind, duplicate machines have been installed in a ship. By the arrangement of Mr. Kennedy one-half of the machine would be able to do the work while the other half was being repaired, so that in fact the whole consists of what may be termed a modified set of duplicate machinery. It is unnecessary to enter into detail as to the construction of this machine, as except in its mechanical modification it is similar to the single armature machine.

NOTE ON WATTS AND HORSE-POWER ELECTRICAL.

BY DESMOND G. FITZ-GERALD.

Misapprehensions as to the value in watts of the horse-power electrical have occasionally arisen in consequence of the following relations, viz. :—

1. The horse-power electrical, taken as 746 B.A. watts, is equivalent to only 736 true watts.
2. The horse-power electrical is equal to 756 B.A. watts.
3. The horse-power electrical is equal to 746 true watts.

In absolute C.-G.-S. e.m. units, taking the force of gravity as $g = 981$ *dynes*, Watt's horse-power of 550 foot-lbs. per second is $7 \cdot 46 \times 10^9$ *ergs* per second.

The watt (ampere × volt) $= 10^{-1} \times 10^8 = 10^7$ *ergs* per second.

Thus we have, as the value in true watts of the horse-power electrical—

$$\frac{7 \cdot 46 \times 10^9}{10^7} = 746.$$

If our standard expressing the volt be too small, and that expressing the ohm also too small proportionately, current, in the expression (ampere × volt), will not be affected ; but our watt will be affected by our standard of e.m.f., and will consequently be too small. Since the standard of e.m.f. corresponding to the B.A. standard of resistance is ·98677 true volt, 746 B.A. watts will be $746 \times \cdot 98677 = 736$ true watts ; and $\frac{746}{\cdot 98677} = 756$ will be the value in B.A. watts (or in watts as measured by the B.A. standard of resistance) of the electrical horse-power.

The "force de cheval," which is adopted by some electricians in this country, as well as abroad generally, is defined as 75 kilogrammètres $= 7 \cdot 36 \times 10^9$ *ergs* per second. It is therefore 736 watts, and thus happens to be the same as what may be called the B.A. horse-power—*i.e.*, that of 746 B.A. watts.

Judging Colours.—The *Chemical Trade Journal*, in ostensibly discussing the question of dynamos and electro-motors while in reality describing Cuttriss's dynamo and motor, says :—The dyer, the calico-printer, and paper-maker has often before him the task of judging minute differences in colour shades, and if the day is at all dull it is next to impossible to do so accurately, and to attempt to judge by the light afforded by ordinary coal gas is out of the question altogether. Having power at hand, the possession of a small arc light is a problem of the simplest character, and satisfactory results may be obtained with the minimum expense. Incandescent lamps will not answer satisfactorily for colour judging, and though it has been stated that glow-lamps may be used, yet those who have employed them for this purpose give anything but a good account of them. Several calico-printers in the neighbourhood of Manchester have already adopted arc lights in some portions of their establishments, and we have seen the same working in a most satisfactory manner in more than one works ; still, most mills are fitted throughout with gas, and it requires very strong pressure to induce a manufacturer to change from a system he has had in operation so long.

ELECTRICITY IN ITS RELATION TO THE MECHANICAL ENGINEER.*

BY PREST. G. H. BABCOCK.

Yet another great force, or manifestation of force, in nature is already yielding its neck to the yoke prepared for it by the mechanical engineer. Electricity had long been known as a terror, and had been played with as a toy, but our own Franklin, in this very city where we are now assembled, was the first to show that the terror and the toy were one. Other ready hands took up the work of subduing it, and now it rings our call bells, lights our gas, watches sleeplessly in our dwellings for burglars, regulates the heat in our rooms to a fraction of a degree, makes our plated ware and electrotypes, duplicates our medals, and starts our exhibitions at the nod of a president or a king a thousand miles away. It floods our streets and public halls with light, and furnishes a tiny fire-fly lamp to explore the inner recesses of our bodies. It drives our sewing machines and our street cars, and is even trying its hand at boats and railways. It concentrates into a point the heat equivalent to 500 horse-power of work, and vapourises metals we have scarcely been able otherwises to melt. It welds together rods and shafts, as it were, with a touch, and smelts the most refractory ores.

But I need not enumerate the wonders which mechanical genius and skill have wrought in this our day, in the line of the first grand commission to "subdue the earth." You see them all about you.

The question only remains: What will be the outcome? To what shall we look forward as the field for future achievement? Can we go on at the same rate of advancement, or must we stop for want of other worlds to conquer? Towards the end of the last century—after Priestly had discovered oxygen—Galvini had found the supposed secret of life, the Leyden jar had shocked crowned heads as well as philosophers. Watts had brought steam into practical use, Arkwright had invented the spinning frame and Cartwright the power loom, Murdock had begun lighting buildings by gas. Cort had invented the puddling furnace and the rolling mill, and Tennant had produced chloride of lime and applied it to bleaching purposes—a prominent scientist said that there could be no probability that the next age would advance as rapidly as that had done. But discovery has followed discovery in a geometrically progressing ratio, until, at the present time, we stand aghast, and say, "What can come next?" It is, however, probable that the future will bring many a discovery and application of knowledge, as far beyond anything we can now imagine, as sewing machines and mowing machines, railroad and steamships, celluloid and dynamite, rock drills and rotary printing presses, vulcanised india-rubber and Bessemer steel, boring for oil and burning water-gas, photography and the phonograph, electric light and electric smelting, the telegraph and the telephone, the spectroscope, and hundreds of other discoveries and inventions of the nineteenth century were beyond the thoughts of our grandfathers one hundred years ago.

But though we cannot foretell what wonderful things may be in store for us in the future, we may at least speculate a little, based upon the knowledge we now have. I have spoken of the probable exhaustion of our coal fields and the necessity of finding some substitute. There is a source of heat fully capable of supplying all we need, if it can be utilised; that is the sun. It has come to be generally admitted that coal is in a sense nothing but condensed sunlight stored up in ages past for our present use. Now, if we can only devise means for imprisoning the heat of the sun, so as to use it as we may need it, then we can abandon our coal mines and forget that they ever existed. The amount of this heat in one minute, as determined by the United States expedition to Mount Whitney, is sufficient to heat one gram of water three degrees centigrade for each square centimetre of the exposed surface of the earth. But this conveys little idea to the mind not educated to think in such measures. It may be better understood if we say that it is equivalent to the heat generated by the combustion of, in round numbers, one thousand millions of tons of coal for every minute in the year; or one million three hundred thousand times as much as is now mined.

Already an honoured member of our Society, Captain Ericsson, has shown us how a portion of it can be conserved. But the question may be asked, What would be the result upon the condition should this heat, which now goes to warm the earth and promote vegetation, be used for other purposes? To this it may be answered, that, as the earth does not grow warmer year by year, all the heat it receives must either be changed to other forms of energy or be radiated into space. It is likely, therefore, that the heat radiated from the earth is nearly as great as that received, and possibly some way may be discovered to catch it on its outward journey, if it be found that the amount necessary for the purpose would rob nature of her share. But, as the burning of 400,000,000 tons of coal, and probably as much more wood, upon the earth, per annum, does not seem to perceptibly alter the character of our seasons, it is probable that a similar amount taken from the heat received from the sun would not produce a noticeable effect upon the processes of nature.

But we must learn to conserve our heat better, and instead of the present wasteful mode of making power by means of steam, by which only one-tenth of the heat generated is utilised, some better means must be discovered of turning heat into work. The generation of electricity directly by the combustion of coal has often been suggested as a possible thing, and one of our members, Mr. Edison, is even now working with some success upon the problem. Should future genius succeed in utilising the heat as fully in a thermo-electric generator as is now done in our steam boilers, the coming age will get its power at one-fifth the cost of the most economical engines of this day, and then, if the radiant heat of the sun can be caused to take the form of electrical force, factories, railroads and steamships will be driven and lighted with no expense beyond the interest and wear and tear of the machinery.

It is not, however, necessary for us to wait for the discovery of this efficient thermo-electric generator before we can conserve our fuel. We now have means by which the water power, which is going to waste, can be transmitted to localities where more power is demanded. Electric dynamos have attained to as high as 90 per cent. efficiency, and if they can be made perfectly reversible, which, at least, seems probable, we should be able to transmit power with comparatively small loss. The water-power of the world is estimated at 200,000,000 horse-power, and when we shall have conserved this we shall have enough to supply the world's work for years to come; then there is the enormous energy of the tides and of the winds, which might be added thereto, when we have perfected storage batteries, so that the extremes of effort of such forces may be graded down into a constant mean.

In looking about for fields to conquer, the question springs to the mind, Shall we ever fly? That has been one of the dreams of mankind from the earliest ages. He has looked upon birds as they have sailed through the air, apparently without effort, and has wondered why he could not attain the same mode of motion. Why not? It is simply the question of sufficient power within a given weight. The weight of our steam engines per horse-power has been decreased 37 per cent. in the last five years, and we are not at the end. We are also reducing very rapidly the weight of our dynamos and electric engines in proportion to their power, so that it is now but one quarter of what it was five years ago. When man has learned to generate power with, say, one-tenth the weight of apparatus that is now required, then, by making the framework of his flying machine of aluminium tubes, there is no good reason to doubt that he will become master of the air, as he is now master of the water, and will be able to fly from place to place with all the certainty and safety of a bird.

But I will not detain you by any further speculations as to the future triumphs of our profession. That they will be great does not admit of a doubt in view of the past. That they will be more wonderful and important than we can now comprehend is probable from the analogy of history. That they will elevate and ennoble man, lift him

* Portion of opening address at the meeting of the American Institute of Mechanical Engineers, Philadelphia, Nov. 28, 1887.

out of many of his present limitations, and make him the master where he now is the victim is certain, because that has always been the effect heretofore, and because it is the end for which the engineer is commissioned. This society is to be a factor in such result. Its every meeting to mingle experiences, to discuss causes, to compare attainments, and to encourage research is a step toward the final achievement, when every force of nature and every created thing shall be subject to the control of man.—*Electrical World.*

THE ELECTRIC LIGHTING OF THEATRES.

BY DR. G. SOUS.

(*Continued from page 41.*)

Spasm of the cilliary muscle, producing temporary myopia, can only be the consequence of the intensity of the light. The pupil contracts in order to diminish the quantity of light reaching the eye, and the connection between the iris and the cilliary muscle is so close, although not identical in different individuals, that we may say that the contraction of the iris has brought about the contraction of the cilliary muscle.

The cases of temporary *conjonctivitis*, which have been indicated by M. Javal in professional electricians, may, perhaps, be occasioned by the production of the gases referred to by M. Fieuzal. I advance this as a question without having the pretension to offer a solution, as I have before me no case in my private experience.

The cases indicated by Nodier, Rockcliffe, &c., are of greater importance. It is here a question of lesions affecting the sight, and *primâ facie* one is inclined to consider these facts as being analogous to those observed after direct insolation of the eyes.

After observing eclipses of the sun, after astronomical inspection of this body, and after nautical observations with a sextant, many persons have experienced unpleasant symptoms produced by the intensity of the solar light. Many cases have been published, and I have myself investigated several more, especially at the period of the eclipse in 1882, or in the case of nautical captains who had passed a lengthened period in the equatorial regions when becalmed. When these cases, evidently due to the intensity of the light, are studied, it is observed that the disease is not attended with any intense pain in the eyes, and that central *scotomes* of greater or less extent are present, and may persist in darkness. Persons who have occasion to examine the carbons in arc lights experience other symptoms, namely, violent pains in the eyes and photophobia. Thus in 1880 I noted the following fact: On the 14th July M. D—— had installed at the Nantes Hotel a system of lighting which he had patented under the name of the unextinguishable electric candle. In order to observe the separation of the carbons and the action of the apparatus, M. D——, whose eyes were provided with dark blue glasses, frequently looked closely into the electric light. During the night he was seized with violent pains in the eyes. He seemed to perceive the burning carbons, and not only with his eyes but within their orbit. The weakest light had become intolerable, owing to its increasing the pain. It was in a completely darkened room, and without being able to make any examination, or even to perceive anything whatever, that I was called upon to meet the patient, and to hear the account of his sufferings and his experiences. I prescribed compresses saturated with water of the cherry laurel, permanently applied; and after two days all the symptoms had disappeared, the cure being complete. In the employment of blue glasses M. D—— made a complete mistake. Blue glasses diminish the intensity of light, but allow of the passage of the blue and violet rays. The progress of the lesions produced by the direct rays of the sun are altogether different. In such cases, as is shown by the experiments of Czerni, the layers of the retina may be destroyed and be replaced by pigmented connective tissue; hence the persistant and sometimes obstinate *scotomes* which are observed.

If the electric rays give rise to phenomena differing from those produced by solar light, the cause is to be attributed not to their luminous intensity, but to the chemical rays and to the fluorescence resulting from their action. "The artificial lights at our disposal, which are much weaker than the light of the sun, say Alglave and Boulard, are not injurious by reason of their intensity, but owing to their particular character" ("The Electric Light," page 160).

Regnault and Foucault have indicated fluorescence of the cornea produced by chemical rays. De Chardonnet assumed that the physiological function of the crystalline lens is to intercept all ultra-violet radiation. This conclusion is too general, for Donders, Rees, Brücke, and Helmholtz have made known experiments which establish the fact that the violet and ultra-violet rays may reach the retina, and that this organ does not escape fluorescence.

Fluorescence of the retina, of the cornea, such is the cause of the symptoms observed after the direct action of the (arc) electric light. It is impossible to take too great precautions against this injurious effect.

The cause being known, we have the remedy to hand. It is by surrounding the foci with protective substances, by preventing their effects by means of screens, that we shall obtain the desired end. The light must be modified by means of glasses, or else the apparatus must be so arranged as to give only reflected light.

"Lighting," says M. Trélat, "is properly carried out only when the eye is shielded from the immediate effect of the luminous source. The eye when exploring the illuminated space should never be directly exposed to the luminous focus. When small sources of light only are at our disposal we are obliged to bring them into close proximity to the space to be illuminated. In this case it is difficult to prevent the direct rays from reaching the eye, but with electric lighting, properly understood, it is easy to do so. It suffices to have the luminous foci sufficiently intense, and to place them at a sufficient height."—"Medical Progress," 1881.

In order to shield their eyes from the luminous focus, the readers at the British Museum library adopted a means which would scarcely be practical in a theatre. We read the following in the *Journal Universel de l'Electricité* for the year 1886, in relation to the above library:—"Several of the readers protect themselves against the rays from the lamps by means of sunshades."

At the theatre suitable glass globes would be more convenient than sunshades.

All these globes made of more or less opaque glass, enamelled or ground glass, &c., augment the surface of the luminous source, render the shades less hard by the extension they give to the penumbra; but they absorb more or less light according to their arrangement and their thickness. When any substance is rendered translucent instead of transparent, light is always sacrificed. The use of these globes may be continued, but in the illumination of theatres the lower portion only should be rendered partly opaque, leaving the whole intensity of the light to be radiated upwards to the ceiling. In this manner the foci would be subtracted from direct vision, and the spectators would receive only the light reflected from the upper portion of the enclosed space.

As the ceilings of theatres are not plane surfaces it may be well to examine what should be the position of the electrolier constituting the main source of illumination. The ceiling may be related to the circle or to the ellipse. I speak here of the generatrix of its surface, and not of the form of its limiting curve.

If the generatrix be a circumference, the ceiling becomes a concave mirror, and by placing the electrolier midway on the radius of curvature all the luminous rays will be reflected perpetually into the enclosure, and will not directly reach the eyes. If the generatrix be an ellipse, the foci of the ellipse must be located where there are no spectators—in front of the upper seats, for instance. If, from each focus of the ellipse a line be drawn to the limit of the ceiling, we shall have a surface limited above by the ceiling, and below by the intersection of the lines drawn from the foci. It is in this surface that the electrolier should be placed. In this case the maximum of the rays reflected by the ceiling will be at the foci of the ellipse—that is, at a place where they will not meet the eyes of any spectator.

In lieu of opaque globes coloured glasses might be employed. The utility of these glasses is in modifying the spectral composition of the electric light. Yellow glasses might here be useful, not with a view of producing a yellow light such as would occur in the case of a source of white light, such as the sun or magnesium.

Yellow glasses may be obtained in different ways. Chromium, carbon, antimony, uranium, and various salts of silver are substances, which, when added to ordinary glasses, produce a yellow coloration. They are not all of the same value in relation to the chemical rays. Those manufactured with uranium obviate fluorescence, but they are dichroic, and would thus have a bad effect in theatres. Chronium glass is to be preferred, for it removes the most refrangible portions of the spectrum; in other words it destroys the blue and violet rays of the spectrum, and consequently the chemical rays.

According to Dr. Stone, *Journal Universel de l'Electricité*, July, 1884, the electric light is detrimental to the eyes; that which is produced by the voltaic arc in consequence of the excess of chemical rays, and that from incandescent lamps by reason of a preponderance of calorific rays. In order to neutralise these effects, our *confrère* has had manufactured spectacles formed of blue and red glasses. The blue glasses are placed in front and the red glasses at the sides. The blue glass is used when the light is produced by incandescence, and when this is due to the voltaic arc the red glass is folded over the blue glass. These spectacles are but little known in France.

THE LIGHT BY INCANDESCENCE.

It has been said that the voltaic arc gives *wholesale*, and the incandescence lamps *retail* illumination. In point of fact the former is adapted for large spaces, and the latter for spaces of

restricted dimensions. There are, however, other differences. The incandescence light is more steady, more continuous, and less flickering. It is less intense, and moreover, from its spectral composition, it approximates closely to the illumination our eyes are accustomed to. Thus, a 10-candle incandescent lamp surpasses a Carcel lamp only by two candles at the most. Thus we see these lamps in use without opaque globes in dwelling houses and at theatres. It is, in fact, in this direction that their useful application lies, and they advantageously replace less effective methods of illumination without having any detrimental effect so far as has been observed.

In most theatres 10 candle incandescence lamps have most generally been employed. At the opera there are 165 Edison 10 candle lamps equivalent to 200 Carcels. Under these conditions the precautions to be taken are merely those which would be advisable in any general case of lighting.

To sum up, the light from the voltaic arc, containing a large proportion of chemical rays, is detrimental to the eye. It supplies a powerful and energetic method of illumination. It is adapted for public spaces, for enclosures of vast extent, and necessitates that precautions should be taken to obviate its detrimental action. The light obtained by incandescence is more steady and less intense; it resembles in its spectral composition the ordinary artificial lights, and its possible drawbacks are merely such as would be due to an excess of any artificial illumination. It is the light best adapted by its nature and degree of intensity for the illumination of apartments and meeting places, and it is with good reason that it has been preferred generally for the illumination of theatres.

PORTABLE VOLTMETERS FOR MEASURING ALTERNATING PORTABLE DIFFERENCES.

BY PROFESSORS W. E. AYRTON AND JOHN PERRY.

(Continued from page 44.)

E.—Uniformity of the Scale Divisions.

It is rather important to notice that from (9) it follows that the smaller is $\frac{s}{r} y_0$ the more uniform become the divisions of the scale.

Now from (15), $y_0 = \frac{t^3 l_0}{4 L b q} \phi_1$; so that $\frac{s}{r} y_0$ being small means, since $s = \frac{b}{a}$, that $\frac{1}{a\,r} \frac{t^3 l_0}{4 L q} \phi_1$ is small, or that $\frac{t^3 l_0 \phi_1}{4 L q a r}$ is small. But as a large maximum value of the deflection is very important, and as this, as we have seen, requires that t and r should be small, and that l_0 and q should be large, the only way in which we can simultaneously satisfy both sets of conditions is to make $n\,q$ large—that is, by using thick wires, many wires (as many wires as possible), and very thin strips for our magnifying spring. Using thick wires, however, diminishes the range of volts that can be measured.

Finally, it is to be observed that the condition of most importance in obtaining

(1) A large maximum deflection,
(2) Uniformity of the divisions of the scale,
(3) A large range of volts that can be measured,

is to make the strip of which the magnifying spring is made *as thin as possible*.

F.—Correction for Temperature.

In what precedes we have disregarded the effect produced by the variation of the temperature of the instrument as a whole, caused partly by variations of atmospheric temperature, and partly by the warming up of the whole instrument by a prolonged maintenance of the potential difference at its terminals. We will now investigate the magnitude of the error so caused.

Let a be the coefficient of expansion of the stretched wire;
β be the coefficient of expansion of the framework supporting the ends of the wire;
y_0 be the dip $O\,Q$ (Fig. 10) at the temperature of graduation;
y_t ,, ,, t° C. above ,, ,, ,,
y ,, ,, $\theta + t^\circ$ C. ,, ,, ,, ,,

then
$$y_0^2 + A Q^2 = \tfrac{1}{4} l_0^2,$$
$$y_t^2 + A Q^2 (1+\beta t)^2 = \tfrac{1}{4} l_0^2 (1 + a\,t)^2,$$
$$y^2 + A Q^2 (1+\beta t)^2 = \tfrac{1}{4} l_0 \{1 + a(\theta + t)\}^2;$$
$$\therefore y^2 - y_0^2 = \tfrac{1}{2} l_0^2 a\,\theta + \tfrac{1}{2} t (l_0^2 a - 4 A Q^2 \beta).$$

If the initial dip at the temperature of graduation be small,
$$4 A Q^2 = l_0^2, \text{ approximately};$$
$$\therefore y^2 - y_0^2 = \tfrac{1}{2} l_0^2 \{a(\theta + t) - \beta t\}.$$

Let
$$a - \beta = \gamma,$$
where γ can be made positive, nought, or negative by compensation of the framework of the instrument for changes of temperature. Hence
$$y^2 - y_0^2 = \tfrac{1}{2} l_0^2 (a\,\theta + \gamma t) \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Also, if ρ_0 be the specific resistance of the material of which the wire is made at the temperature of the framework of the instrument during graduation; and if ρ be the specific resistance when the framework of the instrument is at a temperature t° C. above that of the temperature of graduation, and when the wire has a temperature θ° C. above that of the framework,
$$\rho = \rho_0 \{1 + k(\theta + t)\}.$$

Consequently, following the reasoning previously given, connecting the rate of loss of heat by radiation and convection, and the rate of production of heat by the passage of the current, we have
$$\theta = \frac{V^2 d}{4 l_0^2 \epsilon \rho \{1 + k(\theta + t)\}}, \text{ approximately.}$$

Substituting in (17) the value for y given in (6), and for θ the value just obtained, we have
$$\phi^2 + 2 \frac{s}{r} y_0 \phi = \frac{s^2}{r^2} \tfrac{1}{2} l_0^2 \left(a \frac{V^2 d}{4 l_0^2 \epsilon \rho_0 \{1 + k(\theta + t)\} + \gamma t} \right)$$
$$= \frac{s^2 d\,a V^2}{r^2 8 \epsilon \rho \{1 + k(\theta + t)\}} \left(1 + \frac{\gamma t}{a\,\theta}\right)$$
$$= \frac{A V^2}{(1 + k\theta)\left(1 + \frac{k t}{1 + k\theta}\right)} \left(1 + \frac{\gamma t}{a\,\theta}\right),$$
or,
$$\phi^2 + 2 \phi_0 \phi = \frac{A V^2}{1 + k\theta} \left(1 - \frac{k t}{1 + k\theta} + \frac{\gamma t}{a\,\theta}\right), \quad . \quad . \quad (18)$$
approximately.

Now formula (8), obtained on the assumption that the framework of the voltmeter always remained at the temperature it was at during the graduation of the instrument, may be written
$$\phi^2 + 2 \phi_0 \phi = \frac{A V^2}{1 + k\theta};$$
hence the effect of the whole instrument being heated up to t° C. is to diminish the right-hand side of the equation by the fraction $\frac{k t}{1 + k\theta}$ of itself, in consequence of the increase of the resistance of the stretched wire; and to increase the right-hand side of the equation by the fraction $\frac{\gamma t}{a\,\theta}$ of itself, in consequence of the difference of the co-efficients of expansion of the stretched wire and the framework. If γ, the difference between the co-efficients of expansion of the stretched wire and of the framework be selected so that
$$\gamma = \frac{a\,k\,\theta}{1 + k\theta}$$
then for that particular value of θ there will be no temperature error of the instrument. Now the effect of γ not being nought will be to cause a slight motion of the pointer when the whole instrument is warmed up as a whole without any potential difference being maintained at its terminals; or, in other words, γ produces what may be called a zero error. Hence the zero error can be made such that there is no temperature error when the instrument is required to measure a certain definite potential difference or a potential difference of about that value. If, on the other hand, the framework of the instrument be so constructed that γ is nought—that is, so that there is no zero error—then the deflection corresponding with any given number of volts maintained at its terminals will be somewhat diminished as the instrument warms up as a whole. In order that accurate readings may be able to be made of small potential differences giving deflections near the zero it will be desirable to make γ small, but whether it ought to be made absolutely nought or not can only be determined by practical experience of this new form of voltmeter extending over some time.

Solving (18), we have
$$\phi = -\phi_0 + \sqrt{\phi_0^2 + \frac{A V^2}{1 + k\theta}\left(1 - \frac{k t}{1 + k\theta} + \frac{\gamma t}{a\,\theta}\right)} \quad . \quad (19)$$
and in order to estimate the magnitude of the error arising from the terms involving t let us consider the values of the constants in the previous expression. In some of our instruments we find that the initial sag y_0 is about 0·5 centimetre, and that $y - y_0$ is about 0·22 centimetre when ϕ is about 280°—that is, when the needle is deflected to the limit of the scale. Therefore, since
$$\phi_0 = \frac{s}{r} y,$$
and
$$\phi = \frac{s}{r}(y - y_0),$$

it follows that $\phi = \frac{\phi_\circ}{2}$, approximately,

when the deflection has about its maximum value. Hence, if we write X for $\frac{A V^2}{1 + k\theta}$, X' for $\frac{A V^2}{1 + k\theta}\left(1 - \frac{kt}{1+k\theta} + \frac{\gamma t}{a\theta}\right)$ and ϕ' for the value of ϕ when X becomes X', we have

$$\phi = -2\phi + \sqrt{4\phi^2 + X}, \text{ approximately,}$$

and $$\phi' = -2\phi' + \sqrt{4\phi'^2 + X'}, \quad \text{,,}$$

therefore the proportional error when the deflection is a maximum

$$\frac{\phi - \phi'}{\phi} = \frac{\sqrt{\frac{X}{5}} - \sqrt{\frac{X'}{5}}}{\sqrt{\frac{X}{5}}}, \text{ approximately,}$$

$$= 1 - \sqrt{1 - \frac{kt}{1+k\theta} + \frac{\gamma t}{a\theta}}, \quad \text{,,}$$

Now k equals 0·00031 and a about 0·0000145 for platinum-silver; also θ is about 250° C. when the deflection ϕ is about 280°. Let t, the temperature through which the case of the instrument is raised above the temperature of graduation, be 50° C.: then, if γ be nought,

$$\frac{\phi - \phi'}{\phi} = 0{\cdot}007, \text{ approximately;}$$

that is, ϕ is diminished by about 0·7 per cent., in consequence of the increase of resistance of the stretched wire. And this temperature error can be made still less by giving γ a negative value—that is, by making the framework of the instrument have a larger coefficient of expansion than the stretched wire. For instance, if the framework which carries the stretched wire have a coefficient of expansion rather less than that of copper, the temperature error of the voltmeter in the higher parts of the scale will be practically nought.

The accuracy of the instrument depends, among other things, on the constancy of the elasticity of our magnifying springs. To test this we have had tests conducted regularly during the last two years on one of our magnifying spring ammeters. The current was measured absolutely on each occasion by the silver-deposit method, and, as this can be done more easily and accurately if the current be rather small, the ammeter selected for this series of tests was one that gave the maximum deflection (of about 270°) for 1½ amperes. Of course the only difference between this ammeter and a magnifying spring ammeter measuring a much larger current is in the gauge of wire used in the winding, and not at all in the spring; therefore any conclusions as to constancy that may be drawn from the results of the tests are equally applicable to any other magnifying spring ammeter. Sixty-four distinct tests have been made by different groups of students in the two years; and to impress on the students the importance of making such time tests of an ammeter, as well as to prevent their imagining that the silver-deposit test ought to give the same values for the currents as are indicated by the graduations of the scale of the ammeter, the students were warned that the ammeter had been intentionally graduated with an error—the error, in fact, being that the ammeter reads from 1½ to 2 per cent. too low.

Instead of giving the tests in the exact order in which they were taken, each group of tests is, for convenience of comparison, arranged in chronological order. (Table A.)

As the tests were made by a large number of different students, having very different aptitudes for such work, some of the results arrived at were obviously wrong, and have been rejected; but, excluding these few exceptional ones, the preceding are a fair sample of the results obtained, and we see that it is impossible to conclude from them whether the ammeter has become more or less sensitive during the two years. In other words, its sensibility for practical purposes has remained quite constant. The temperature was carefully recorded after the early part of 1886, since it was thought that perhaps some temperature error might become visible; but this has not turned out to be the case, so that *the temperature may be apparently neglected in using a magnifying spring ammeter.* With a magnifying spring voltmeter wound with copper wire there will, of course, still remain the error due to a variation of the resistance of the coil with temperature; but the important result that has been arrived at is that *the indications of a magnifying spring ammeter or voltmeter, when a given current is passing through it, is not altered by age or by the ordinary changes of temperature of a room.*

To further test this latter point a magnifying spring ammeter, adjusted so that the needle stood exactly at zero when the temperature was about 15° C., was placed in a bath and heated up to 40° C. for five hours; but no change in the zero could be observed, which would have been the case if the elasticity of the spring had sensibly varied, seeing that the weight of the soft iron cylinder was hanging at the end of the spring all the time. We feel, therefore, quite safe in using the magnifying springs for our new type of voltmeter.

TABLE A.—*Tests made with a Magnifying Spring Ammeter initially graduated from 1½ to 2 per cent. too low.*

DATE.	Temperature in Degrees Centigrade.	Reading on Ammeter.	Amperes by Silver Voltameter.
6th October, 1855	...	0·588	0·592
19th July, 1886...	21	0·58	0·59
5th October, 1886	21·8	0·58	0·596
,, ,, ...	17·5	0·50	0·571
16th November ,, ...	15·8	0·5	0·514
6th October, 1885	...	0·65	0·682
14th ,, ,, ...	...	0·65	0·666
10th March, 1886	13	0·600	0·615
10th ,, ,, ...	13·8	0·64	0·657
10th ,, ,, ...	14	0·68	0·692
21st July ,, ...	22·8	0·663	0·683
8th October ,, ...	17·5	0·620	0·635
22nd ,, ,, ...	17·5	0·67	0·688
9th November, 1886 ...	13	0·60	0·615
6th October, 1887	18·4	0·60	0·618
3rd August, 1885	...	0·76	0·776
6th ,, ,, ...	...	0·76	0·776
14th ,, ,, ...	...	0·757	0·775
18th November, 1885 ...	12	0·700	0·721
18th ,, ,, ...	...	0·721	0·744
9th December ,, ...	8	0·70	0·72
17th February, 1886 ...	14	0·700	0·727
24th ,, ,, ...	16·1	0·720	0·746
23rd July, 1886...	20·5	0·722	0·749
6th October, 1887	18·4	0·70	0·711
19th ,, ,, ...	16·5	0·70	0·716
25th October, 1886	15·6	0·84	0·859
22nd February, 1887 ...	15·6	0·80	0·820
5th October ,, ...	16	0·80	0·821
5th ,, ,, ...	16·5	0·80	0·828
16th ,, ,, ...	17·25	0·80	0·813
1st November ,, ...	16·6	0·80	0·814
1st ,, ,, ...	16·6	0·84	0·861
15th February, 1887 ...	13·5	0·90	0·916
1st March ,, ...	12·2	0·90	0·920
8th November ,, ...	18·8	0·91	0·929
30th July, 1885	...	1·06	1·073
3rd December, 1885 ...	...	1·008	1·022
7th ,, ,, ...	9	1·07	1·096
9th ,, ,, ...	7·5	1·12	1·14
14th ,, ,, ...	14	1·12	1·14
27th October, 1886	14·6	1·147	1·160

We are now engaged in devising various means for compensating this new form of voltmeter for temperature errors; but before actually introducing these compensations into the instruments one of our students—Mr. Kilgour—has been carefully measuring the exact coefficient of expansion with temperature of fine platinum silver wire under a tension which is comparable with its breaking tension. The compensation for the short-tube form shown in Figs. 3 and 4 will probably in part consist in the device adopted by Captain Cardew of making the support to which the wires are attached of a compound metal, while in the case of our bicycle-wheel form the rim to which the wires are attached will probably be made like the balance-wheel of a chronometer; but, of course, the same accuracy of adjustment for temperature that is necessary in a chronometer will be quite unnecessary in the voltmeter, as the error is not a cumulative one as it is in a chronometer.

The following, we venture to think, are the improvements that we have been led to introduce into the Cardew voltmeter by employing the devices that we have described:—

1. A small alternating potential difference can be accurately measured, as the wire in our instrument may be short, and as the readings can be taken down to the zero with certainty.
2. With the same instrument a wide range of volts can be measured, since with many short wires combined with a commutator any number of them can be put in series; that is, any length of wire can be electrically used.
3. Whatever number of volts is being measured, all the wire is directly active in deflecting the pointer, which is not the case with an instrument provided with an external resistance for increasing the range.

4. The instrument is compact and portable.
5. Great dead-beatness of action is secured by the employment of much finer wire than has hitherto been commercially used, and by the magnifying gearing being frictionless and comparatively massless.
6. Non-liability of even such fine wire to break from a blow, in consequence of the frictionless and comparatively massless character of the magnifying gearing to which the wire is attached.
7. Diminution in the power wasted in the instrument by the employment of a short instead of a long wire.

INSTITUTION OF ELECTRICAL ENGINEERS.

PRESIDENTIAL ADDRESS.

(*Continued from page 47.*)

The operations of the telephone as yet are of a more limited character, but even as at present developed are of little less interest. The telegraph may be regarded, in the main, as the rapid public transmitter of private or public correspondence; the telephone as the instrument of personal, and therefore strictly private, communications between man and man. If the communication is perfect, and so arranged as to be free from interference, not only can the varying sounds of voices be recognised through the connecting wire, but the tones may be distinguished in many cases, and the speakers known. One individual can speak freely to another, obtain his answer, and make any rejoinder he thinks fit. An entire business transaction can be completed without any pre-arrangement, and confidential questions can be equally confidentially replied to. Reis advanced the discovery of the means of transmitting the effects of speech to the verge of success, but did not pass the verge. Bell completed what Reis had begun, and placed a workable instrument at the disposition of the world. Edison and Hughes strengthened the forces employed for the transmission of sound waves, and the telephone (as we know it) was completed. Founded upon the laws that guided the production of the telegraph, the generation of the telephone was especially rapid; but a brief space has elapsed between its inception and its realisation. The marvels it has wrought are less striking than those of the telegraph, but the processes by which they are produced appear more marvellous still. At present the operation of wide-stretching patents perhaps cramps, to some extent, the improvement of the mechanical apparatus needed for telephonic expression, and time has not sufficed to admit of all difficulties in the way of its extended use being overcome; but seeing how few years have elapsed since the discovery of the thing itself, we may reasonably hope for its much greater development in the near future.

EMPLOYMENT ARISING OUT OF THE VARIED USES OF ELECTRICITY.

There are many indirect methods in which labour is employed, because electricity has been utilised, that do not admit of being ranked under any special head of its operations. Wire-drawers, and, in consequence, iron works, and copper smelting works, also copper-plate rollers, are largely engaged in the production of materials for the transmission of electric signals. Timber dealers and their workmen, creosoters, insulator makers and their *employés*, brass workers, spelter makers, engine builders, boiler makers, glass blowers, carbon plate and rod manufacturers, and very numerous other occupations, receive considerable employment by means of the demands that electricity has encouraged; but as the firms engaged do not generally devote themselves solely to meeting such demands, but exist also for wholly distinct purposes, it is impossible to arrive at any idea of the amount of labour on electrical account that they employ. It is equally impossible to enumerate all the persons engaged in absolutely electrical trades. In Sheffield there are 172 electro-plating and electro-gilding manufacturers, employing in all about 5,000 hands; and in Birmingham there are 99 manufacturers of the same class, two of whom employ 300 persons each, and others a large, though uncertain, number in the aggregate—one thing is certain, it must in the total be very large.

The electro-platers, electro-typers, and the like are so widely spread that it is impossible to collect reliable figures for them—the instances preceding must suffice; a similar conclusion to the former is only possible. It is the more difficult to arrive at any satisfactory determination because it is simply impossible to ascertain how many persons were employed in dealing with the old methods of working in these directions.

In London alone there are, according to the "Post Office Directory" of 1888, 535 commercial firms, of greater or less magnitude, engaged in various operations of which electricity is the mainspring. Some of these firms appear under several trade descriptions, and it is impracticable to assign any reliable figures to the number of their *employés*, but in the total it must be very considerable. Each employer, although carrying on probably several distinct branches of trade, must engage the full time of various persons, in most cases, in each distinct branch. To the London employers must be added the numerous others existing in our provincial towns. I have, however, obtained reliable figures wherever possible. I will first take the case of the British Inland Telegraphs.

The English Post Office employs, solely in the conduct of telegraphic operations, 18,303 persons. These individuals give *all* their time to work in connection with the electric telegraphs; many thousands of others are partially employed in the same work, but they discharge other duties also, and possibly would be required for those duties did not the telegraph exist. I have, therefore, not included them as among those who have found their means of subsistence through the operations of electricity.

To this ascertained number must be added those who are employed by the various railway companies, either in the conduct of their general telegraphic business between station and station, in special duties in connection with the signalling of trains, or in upholding the telegraph lines existing on the different railways. I could not, in the time available, get the figures I wanted from every railway company. I therefore contented myself with those of four great companies, whose entire systems extend over a length of 5,881 miles. I found that they employed 1,627 persons solely on telegraph work, and, as the entire mileage of railways existing in 1887, as given in "Bradshaw's" hand-book, was 19,339 miles, I apply the rule of proportion, with the result that I find the total number of railway servants wholly engaged in electrical work to be 5,383. Many of the railways which go the make up the gross total mileage are small concerns, many are large ones; but as the infinite subdivision of lines multiplies the number of persons employed in carrying out the operations of any branch of work, I do not think that I can be far wrong in applying the ascertained results of the figures I have reliably obtained to the average of the whole railway system.

But, like the Post Office, the railway companies have a very great number of persons partially, though not wholly engaged in similar operations. The men at the numerous signal cabins not only work the levers controlling the fixed signals, but usually manipulate the block telegraph besides. At many small stations, where there is a but a limited force engaged for the discharge of all duties, the booking-clerk works the instrument in addition to his other employments. I do not count either of these classes among the purely electrical *employés*.

The Exchange Telegraph Company, a licensee of the Post Office, engaged mainly in the supply of intelligence of special events to clubs, public institutions, and private persons, employs the entire time of 182 persons, besides the partial time of many others who supply the company with reports and information.

Thus the number of individuals engaged entirely in the transmission of business brought about by the existence of the electric telegraph in Great Britain and Ireland is, as nearly as I can ascertain, 23,868 persons; to which must be added an army of persons who probably find their incomes more or less considerably increased by the same cause, though not entirely dependent upon it.

I intended to confine myself to the economical figures of the British Islands only, but I may remark that if the rule of proportion holds good in this branch of the subject, and the entire mileage of public telegraph wires of all kinds in this country be, as is the case, 229,000 miles or thereabouts, while those of the world approximately amount to 1,800,000—omitting submarine cables—we have, as in the one case 23,868 persons are employed, a total number of 179,748 persons who find a field of labour in the working of telegraphic communication throughout the globe. It is impossible, seeing the varied circumstances existing in different countries—in some there are long mileages of wire connecting comparatively few offices or stations, in others there are short mileages connecting many stations—to say that this total is correctly arrived at, but it cannot fail to be at least an approximation to the truth. In some countries the available figures are indefinite as regards the differences between Governmental lines and wires for railway purposes; in some, telephone lines are mixed up with the figures for telegraph lines. Thus the totals I have given are liable to error, but it is, at any rate, error on the right side, and the number of individuals engaged in their working in all probability will rather exceed than fall short of the numbers I have given. The facts as to the partial employment of individuals not enumerated as telegraphic *employes* is common to all the world, and not by any means limited to the United Kingdom To the known and fully occupied a very large addition must be made to represent the unknown and partially occupied.

The Submarine Telegraph Cable Companies must next be considered. From three of these—the Eastern, the Anglo-American, and the Submarine—I have obtained the actual figures. Their *employes* number in all 2,168. These three companies possess about 36,697 miles of wire, and throughout the globe there are about 107,000 miles of cabled wire. Deducting those cables that are really integral portions of land circuits and which have no separate organisation, the persons employed in working them are treated as if engaged on land telegraphs. By proportion, this total mileage of wire in cables should make the entire number of persons employed, 6,315. Some time ago the Eastern Telegraph Company endeavoured to get up a census of the number of persons employed in submarine working throughout the world, and arrived at a total of 4,844 persons; but I am not certain that all the lines included in the above calculation were existing at the time such census was compiled. I am pretty sure they were not. I take the actual total of persons employed at 6,000.

These cable companies employ also cable ships in repairing and maintaining the submarine lines. Of these I speak more fully when dealing with cable manufacturing companies,

Next in order come the telephone companies. These, in proportion to the number of their wires, of course employ comparatively few persons, as the renters of the lines are their own manipulators; they employ attendants only at Exchange switches; but, nevertheless, the information received from all the companies existing in Great Britain and the North of Ireland shows that their operations give employment to 2,386 persons. To this number must be added that of the company working in Dublin and the south of Ireland; thus the total is raised to certainly 2,500 individuals, probably more. I have no facts upon which I can extend the comparison to the world generally, but, seeing the universal adoption of this means of communication, and the extent of its development in the United States especially, there can be little doubt that the aggregate total of persons engaged in carrying out this form of electrical undertaking must at least reach 30,000.

The electric lighting industry then comes under consideration. From five of the largest concerns engaged in the business of either providing apparatus and mechanism for its production, or utilising such means for the actual installation of the illuminant, I have re-

ceived returns of the average number of their *employés*. These amount to 1,828. The five concerns I applied to, although among the largest, by no means represent the greatest part of the entire industrial army occupied in the like pursuits. I believe that there need be no hesitation in putting down at least 5,000 as the total for our own country; and, keeping in mind the fact that all countries welcome and adopt the new light—some to an extent much exceeding our own—it is reasonably certain that twenty times this number, or 100,000, will not be too great a figure to represent the entire strength of the workers in this field. Along with the electric light companies and the employment they give, I comprise those of the makers and producers of secondary batteries or accumulators mainly occupied in operations auxiliary to the production of electric light.

There remains to be considered the number of persons employed by the submarine cable and insulated wire manufacturing companies, who most of them make also various instruments used in telegraph working and in other electrical applications. The extent of the employment given by them varies considerably, as, of course, cable-making is a somewhat fitful industry—the periods of active construction and of comparative slackness alternate with each other. From the three largest companies on the Thames, I learn that the average number of persons employed by them varies from 5,457 at a busy time to 1,803 at a dull one; this gives an average of 3,630. The trade, so to speak, is more concentrated than in the case of the electric light, and it is probable that about 5,000 persons will be a fair allowance for the entire number engaged in it in these realms.

In the foregoing totals are included the number of persons habitually employed on the cable-laying ships of the various manufacturing companies, as is also the case with the repairing ships belonging to the different cable companies. The vessels represent a kind of international fleet engaged solely in attendance upon the cables in which their owners are interested. They are of all sizes, from the gigantic "Silvertown," "Faraday," and "Scotia," to vessels of 300 tons and 400 tons burden. Our mercantile marine, therefore, must be counted among the occupations benefited by the advent of electricity.

We must not overlook the large body of persons engaged in teaching the aspirants to electrical knowledge. At universities, colleges, and technical schools a new branch of science has been added to the previous curriculum. Professors, demonstrators, and their assistants represent in the whole a very important and numerous class. Their pupils, in an appreciable measure, represent workers ranked in one or other of the occupations I have mentioned, while numerous others have as yet attached themselves to no special field of work, but are preparing to take part in some definite sphere of labour when their studies are sufficiently advanced. It is amongst these regularly trained for the conflict that we must look for our future victories over the inert forces of nature. It is they who will advance that which as yet is struggling with the difficulties that surround the unknown. It is to them that we must look for future discoveries which will make that plain and easy which now has to be sought for through much trial and many errors. In the early days men groped in the dark towards the light, as it were; but our present students of electricity have at their disposal a clear *resumé* of all the achievements of the past to aid them as a torch on their way to fresh operations in the same field.

Finally must be mentioned the techical press. Independently of the papers devoted mainly to other interests, such as *The Engineer*, *Engineering*, and their like, which give large space to electrical subjects, we have in England, America, France, and Germany alone between twenty and thirty organs interested wholly or specially in the publication of facts or opinions concerning the operations of electricity. This department of the press is invaluable in rapidly spreading a knowledge of what is doing by various workers in the electrical field throughout the globe, and is itself a literary outgrowth of the marvellous agent we are regarding.

Considering the foregoing figures, the results come out as follows:—

Employed in connection with	Number of persons.		Probable number of persons employed throughout the world.
British land telegraphs	23,868	...	180,000
Submarine cable companies (mainly British)	6,000	...	—
Telephone companies	2,500	...	30,000
Electric lighting	5,000	...	100,000
Cable-making, and allied businesses	5,000	...	—
	42,368		

Add to these the individuals that cannot be classified, who must amount in the aggregate to at least an equal number, we arrive at a total approaching 100,000, in round numbers, of persons dependent for their employment on the various operations directly connected with electricity in these islands alone, besides a very large addition to the output of various trades, caused by its consumption of the materials they produce. The employment of 100,000 persons means the support of at least 300,000 of the community. An unusually large proportion of young, or at least unmarried, people of both sexes minister to the calls of electrical work, and hence I take the average family at three instead of the usual calculation of four and a half or five.

If these figures represent even an approach to the truth, it is evident that throughout the earth there must be 5,000,000 of people, at least, who would have to seek for other means of subsistence if electricity and its commercial applications had not been made known to man. Thus it is evident that a double blessing has been conferred by the discovery of its potent force—a blessing to the inhabitants of the world at large, who profit by its orerations, and a further blessing to the toiling myriads whose field of labour lies in carrying them out. How great will be the numbers similarly occupied and similarly dependent when a century more has rolled away!

Thus far I have sought to sketch, although briefly and imperfectly, the various modes in which electricity is utilised, and to arrive at some idea of the extent of employment derived by the workers who strive to secure such utilisation. But this is at best an approximation to the truth at the present moment. It is little more than fifty years since the powers of the new agent were first turned to practical account, and since that time the record has been one of continuous and unabated progress. Discovery has succeeded discovery, and invention has followed upon invention. At present many fields are entered upon, but scarcely trodden. Electro-motors and their like have clearly an unknown, an immeasurable field before them. What is done is as nothing to what will be done. The fusion of the influences of sound and light, the laws of heat in relation to the power we are considering, and its equally important bearing upon those of acoustics, open up so many directions in which we may look for future researches to make much that now shows, as it were, through a glass darkly, clear and distinct, if not to ourselves, at least to future generations. The Leyden jar and the frictional machine taught us the true resemblance between the force they made manifest and the awe-striking lightning discharge from the clouds. Later, more tractable and more easily controlled manifestations of the same agent have been discovered, but in their obedience to control they enlarge greatly the sphere of its uses.

As a stander-by, watching the progress that has been made, and is still making, by the earnest workers who have given to the world so much—marking the difference between the knowledge of the present day contrasted with that which existed over thirty-six years ago, when I first knew the difference between a battery and an insulator, and conceived some vague idea of their respective functions—I am struck with astonishment. In 1852 the Rubicon had been crossed, the theorist had given place to the practical worker, but as yet the latter had not advanced very far from the lines laid down by his predecessors; the spirit of the originators was as yet the controlling influence, but the mind of the student was set free, and each month showed the results of unshackled enquiry. New fields, undreamed of then, have been opened; new applications have been discovered by which the powers of electricity have been utilised; known applications have been greatly advanced and extended. In the time of which I speak comparatively few of the *employés* in telegraph working—and that was, speaking broadly, the sole demonstration of electricity that could be commercially cultivated—were attracted thereto by any knowledge of the science upon which it was founded, or interested in the progress it might make; most looked to it as something in the operations of which they could contribute with profit to themselves, remaining ignorant of the laws that governed it, or the reasons why certain apparatus was employed to produce its effects. To them any knowledge they might glean was empirical, the pure result of experience in a contracted form. At the present day an entire change has taken place. Into none of the advanced operations of electricity does a youth engage himself without having some taste or liking for investigation and the acquisition of real knowledge of the subject in which he is interested. Societies such as this best justify their existence in lending aid to those who seek to elevate themselves and to know what can be learned from their predecessors in kindred labours.

A distinguished scientific statesman once described the mere *workers* of electric telegraph machines as "ambidextrous monkeys"—they knew only that moving a certain handle to the right or to the left, or a key up and down, produced signals or marks that were legible at the further end of a wire; but how they produced them, or *why*, they were supremely ignorant. It is not so with the student of modern days. The man who devotes his life to the electric light, motive power, or other allied branches, knows that he must prepare himself by a careful course of theoretical study before he undertakes practical work. He must know the reasons for all that he does.

Thus it is clear to me that in the facts detailed lies the strongest justification for the proposed alteration in the name of our society. In the summary of electrical operations which I have put before you I have given the largest space to the electric telegraph and its results. I am justified in so doing, because the telegraph is the most nearly completed of all the branches into which the laws of electricity are directed. No doubt there is still room to improve its processes, but its pioneer work is done, and it is scarcely possible that the future can yield more than progress, however important, in details. When the Society was first founded, "Telegraph Engineers" was a fitting name, as it was only in telegraph engineering that any considerable number of the followers of the science we are considering were actively engaged. A great change has taken place: positively even more important than it was then, it is now relatively less so. The field has been so carefully reaped that it offers little temptation to the average gleaner. Speaking generally men's thoughts are directed to other channels, where they may seek, in partially explored or unknown regions, the fame and profit that may accrue to those who win victories therein. "Telegraph Engineers" are still the most numerous units in our body, but from the force of circumstances they can no longer be said to be the special representatives of its character. The Institution of "Electrical Engineers" is a title comprehensive enough to include all devotees of the science; no class of workers is singled out for undue prominence, no class is by implication excluded.

The President of the Royal Society, in his recent address, told the members of that learned body that the world wanted a great discovery—that it was most desirable that the nature of electricity should be made known and defined. We may be on the eve of such a discovery, we may be far from it. The problem to be solved—that of the true character of the mysterious agent that seems to pervade all nature—ranks apparently with the equally puzzling one, "What is the soul?" Philosophical and theological students have quarrelled over the latter question for many generations without advancing nearer to a solution. Let us trust that "What is electricity?" may, in the fulness of time, receive an answer which will extend the boundaries of its use to purposes as yet undreamed of, and that the benefits it confers on man may be thereby multiplied many fold.

PROVISIONAL PATENTS, 1888.

JANUARY 2.

20. John Sherrin and John Vaughan-Sherrin, Codrington-road, Ramsgate, Kent, for **The entire or partial propulsion of bicycles, tricycles, and velocipedes by means of electromotors worked by primary batteries.**—(Complete Specification.)

39. Edward Tyer, 28, Southampton-buildings, Chancery-lane, London, W.C., for **An improvement in voltaic batteries.**

40. Edward Tyer, 28, Southampton-buildings, Chancery-lane, London, W.C., for **An improvement in electrical block indicators for railways.**

41. Edward Tyer, 28, Southampton-buildings, Chancery-lane, London, W.C., for **An improvement in voltaic batteries.**

50. David John Morgan, 1, Queen Victoria-street, London, E.C., for **Improvements in ships' lights in connection with ships' mechanical or electrical telegraph systems.**

56. James Yate Johnson, 47, Lincoln's Inn-fields, Middlesex, for **Improvements in the manufacture of the incandescing portion or luminant of incandescence electric lamps.**—(Theodore Mace, United States.)

JANUARY 3.

80. James Raper Thame, 3, Winders-road, Battersea, London, S.W., for **Electro-mechanical automatic apparatus for the sale of merchandise.**

100. Henry Harris Lake, 45, Southampton-buildings, London, for **Improvements in and relating to apparatus for generating electricity.** (William Humans, United States).—(Complete Specification.)

JANUARY 4.

115. Sydney William Baynes, 13, Albert-terrace, Notting Hill Gate, London, W., for **Improvement in the insulation of electric appliances.**

121. William Horsfield, Henry Hibbert, and Samuel Horsfield, Kimberley, Nottingham, for **Electric tree tubs.**

137. John Charles Pürthner, 12, Mariahilfer-strasse, Vienna, Austria, for **Improvements of the apparatus for producing inducted electric streams in the same direction.**—(Complete Specification.)

155. Alfred Julius Boult, 323, High Holborn, Middlesex, for **Improvements in or relating to electrical turnstiles.**—(Otto Ehrling, Germany.)—(Complete Specification.)

JANUARY 5.

208. Owen Charles Dalhousie Ross, 8, Quality-court, London, W.C., for **Improvements in the utilization of waste products from electrical batteries.**

JANUARY 6.

224. Ernst Bohm, Albion Chambers, Finsbury Pavement, London, E.C., for **Improvements in electric incandescent lamps.**

225. Henry Abbott and John Douglas, Albion Chambers, Finsbury Pavement, London, E.C., for **An improved portable electric battery for miners' and other lamps.**

227. Joseph Slater Lewis, Helsby, near Warrington, for **Improving telephonic exchange magnetos or electricity generators.**

242. John Hubert Davies, 23, Andalus-road, Clapham, S.W., for **Improvements in electrical measuring instruments.**

249. James Thorne Roe, of the firm of Blanch, Brain, and Roe, 17, Bristol-Gardens, Maida Vale, W., for **Improvements in electric meters or apparatus for measuring and registering electric currents.**

JANUARY 7.

293. Thomas Parker, of the firm of Elwell-Parker (Limited), 70, Market-street, Manchester, for **Improvements in alternating current dynamo-electric machines.**

295. Thomas Parker, of the firm of Elwell-Parker (Limited), and Edmund Rees, 70, Market-street, Manchester, for **A new or improved electric meter.**

296. Thomas Parker, of the firm of Elwell-Parker (Limited), 70, Market-street, Manchester, for **Improvements in switches for electric circuits.**

302. Thomas Parker, of the firm of Elwell-Parker (Limited), 70, Market-street, Manchester, for **A new or improved electric meter.**

JANUARY 9.

366. Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London, W.C., for **Improvements in electric arc lamps.** (The firm of Siemens and Halske, Germany).

JANUARY 10.

390. Emil Hippolyte Marie Andreqli, 62, Loughborough-park, Brixton, S.W., Surrey, for **Electrical production of halogens and their compounds and utilization thereof.**

396. James Grieve Lorrain, Norfolk House, Norfolk-street, London, W.C., for **New or improved apparatus for converting alternating currents of electricity into continuous currents.**

416. John Henry Tucker, 24, Ravenhurst-street, Camp Hill, Birmingham, for **Electrical measuring instruments.**

424. James Grieve Lorrain, Norfolk House, Norfolk-street, London, W.C., for **New or improved apparatus for converting alternating currents of electricity into continuous currents.**

JANUARY 12.

506. Charles Mark Dorman and Reginald Arthur Smith, 24, Brazenose-street, Manchester, for **Improvements in the construction of suspension fittings for incandescent electric lamps.**—(Complete Specification.)

507. Emanuel Berg, 20, Johannes-str., Berlin, Germany, for **A repetition and controlling signal telegraph.**

531. Henry Edmunds, 47, Lincoln's Inn-fields, London, for **Improvements in, and means or apparatus for and connected with, the generation, distribution, measurement, and control of electricity.**

COMPLETE SPECIFICATIONS ACCEPTED.

FEBRUARY 7, 1887.

1904. Gisbert Kapp, William Henry Snell, and Julian Money Vernon Kent, 70, Chancery-lane, London, W.C., for **Improvements in the construction of transformers.**

FEBRUARY 10.

2130. Francis Jehl, 28, Southampton-buildings, London, W.C., for **Improvements in electrical inductors and commutators therefor.**

2134. Alexander Schanschieff, Gipsy Hill, Surrey, for **Improvements in miners' safety lamps and in galvanic batteries especially suitable therefor.**

MARCH 9.

3560. Edward Cooper Warburton, 4, Mansfield-chambers, 17, St. Ann's-square, Manchester, for **Improvements in holders and fittings for electric lamps.**

3611. George Forbes, 34, Great George-street, Westminster, for **Improvements in laying electrical conductors underground.**

MARCH 12.

3782. Edmund Edwards, 35, Southampton-buildings, Chancery-lane, London, for **Improvements in electric telegraphs.**—(David Kunhardt, Germany.)

3783. Edmund Edwards, 35, Southampton-buildings, Chancery-lane, London, for **Improvements in Morse keys with multiple contacts for simultaneously transmitting the same telegram to several stations.**—(Eduard Cassalette and David Kunhardt, Germany.)

3785. Edgar William Beckingsale, 2, Gresham Press-buildings, Little Bridge-street, London, E.C., for **Improvements in junction and testing boxes for electrical conductors.**

MARCH 15.

3917. Charles Wittenberg, 323, High Holborn, W.C., for **Improvements in registering apparatus for use in connection with telephones.**

JULY 12.

9725. William Phillips Thompson, 6, Lord-street, Liverpool, for **Improvements in dynamo-electric machines.**—(George Westinghouse, jun., United States.)

OCTOBER 20.

14,260. Stephen Curtis Drew, 52, Chancery-lane, London, for **Means for preventing induction in telephonic circuits.**

NOVEMBER 14.

15,588. James Yate Johnson, 47, Lincoln's Inn-fields, Middlesex, for **Improvements in dynamo electric machines.**—(Winceslas Camille Rechniewski, France.)

DECEMBER 2.

16,558. Arthur Wright, 70, Chancery-lane, London, W.C., for **Improvements in apparatus for measuring and regulating electric currents.**

SPECIFICATIONS PUBLISHED.

1886.

13,660. Sir D. L. Salomons and others—**Combination electrical switch.** 8d.

16,109. S. F. Walker—**Miners' electric safety lamps.** 8d.

17,018 M. H. Smith—**Transmitting electric currents in electric rail or tramway systems.** 1s. 6d.

1887.

700. S. Z. De Ferranti—**Electric furnaces, &c.** 8d.

6853. R. W. Eddison. (Tatham and others.)—**Metal cased electric lines.** 8d.

16,653. H. H. Lake. (The De Mier Electrical Train Signal Company.) **Electrical apparatus for railway signalling, &c.** 11d.

15,730. J. Vaughan-Sherren—**Galvanic batteries.** 6d.

1878.

4847. F. J. Cheesbrough. (Sawyer.)—**Electric lamps.** 1s. 1d.

5306. T. A. Edison—**Developing magnetism, &c.** 8d.

1881.

539. E. G. Brewer. (Edison.)—**Electric lamps.** 11d.

1845.

10,919. E. A. King—**Electric Light.** 8d.

1857.

588. C. W. Harrison—**Electric Light.** 1s. 1d.

1879.

4576. T. A. Edison—**Electric lamps.** 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	98 to 100
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	4
28 Oct.	7/6	Anglo-American	100	38
28 Oct.	15/0	— Pref.	100	63
12 Feb., 85	5/0	— Def.	100	14
29 Dec.	3/0	Brazilian Submarine	10	12⅛
16 Nov.	1/0	Con Telephone & Main	1	11-16
28 July	8/0	Cuba	10	12¾
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	4¼
18 Oct.	5/0	— 10% Pref.	10	9½
14 Oct.	2/0	Direct United States	20	9
14 Oct.	2/6	Eastern	10	11¼
14 Oct.	3/0	— 6% Pref.	10	14¾
2 Aug.	5%	— 5%, 1899	100	109
28 Oct.	4%	— 4% Deb. Stock	100	102½
14 Oct.	2/6	Eastern Extension, Australasia & China	10	12¼x
2 Aug.	6%	— 6% Deb., 1891	100	109
3 Jan.	5%	— 5% Deb., 1900	100	105x
2 Nov.	5%	— — 1890	100	102
3 Jan.	5%	Eastern & S. African, 1900	100	103x
12 Jan.	5/9	German Union	10	9¾
14 Oct.	0/6	Globe Telegraph Trust	10	5⅝
14 Oct.	3/0	— 6% Pref.	10	13½
3 Jan.	5/0	Great Northern	10	14x

Dividend.		Name.	Paid.	Price. Wednesday
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105
25 July	10/0	India Rubber, G. P. & Tel.	10	22¼
28 Oct.	12/6	Indo-European	25	39
16 Nov.	2/6	London Platino-Brazilian	10	5
16 March	5%	Maxim Western	1	¼
15 May	5%	Oriental Telephone	11	⅜
14 Oct.	4/0	Reuter's	8	8½
......	...	Swan United	3½	1⅜
28 July	12%	Submarine	100	135
15 Oct.	6%	Submarine Cable Trust	100	97
14 July	12/0	Telegraph Construction	12	38⅝
1 July	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	11⅞
......	...	West African	10	5
1 Sept.	5%	— 5% Debs.	100	93
29 Dec.	6/0	West Coast of Africa	10	5x
31 Dec.	8%	— 8% Debs.	100	114
14 Oct.	3/9	Western and Brazilian	15	9
14 Oct.	3/9	— Preferred	5½	6⅛
......	...	— Deferred	2½	3 3-16
2 Aug.	6%	— 6% A	100	108
2 Aug.	6%	— 6% B	100	105
......	...	West India and Panama	10	1
30 Nov.	...	— 6% 1st Pref.	10	10
13 May, '80	...	— 6% 2nd Pref.	10	6½
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Sept.	6%	— 6% Sterling	100	104

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Dec.	£38,908	- £1,631
Brazilian Submarine	W. Jan. 11	£4,491	...	Great Northern	M. of Dec.	21,600	...
Cuba Submarine	M. of Dec.	3,300	+ £175	Submarine	None	Published.	
Direct Spanish	M. of Dec.	2,004	+ 222	West Coast of America	M. of Dec.	4,300	...
— United States	None	Published.	...	Western and Brazilian	W. Jan. 11	3,613	...
Eastern	M. of Dec.	57,703	+ 4,880	West India and Panama	F. ½ Dec. 31	2,826	- 263

Abbreviations: W., week; F., fortnight; M., month.

NEW ELECTRICAL COMPANIES, 1887.

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Shares.	Deposit.	Total Deposit.
Blockley Electric Lighting and Manufacturing	£20,000	...	£5 0 0	...	...
Eclipse Electric Battery, Limited	100,000	£100,000	1 0 0	£0 10 0	£50,000
Electric Battery Brush, Limited	50,000	50,000	5 0 0	1 0 0	10,000
Extended Electro-Metal Extracting, Refining, and Plating, Limited	150,000	150,000	1 0 0	0 5 0	37,500
Jensen Electric Bell and Signal, Limited	100,000	100,000	1 0 0	0 6 0	37,500
Orient Electric Light	5,000	...	250 0 0	...	...
Platinum Plating, Limited	60,000	59,100	1 0 0	0 5 0	14,775
Portland Electric Light	45,000	...	5 0 0	...	...
Singapore, Straits Settlements, and Siam Electrial, Limited	60,000	39,000	5 0 0	2 0 0	15,600
South Metropolitan Electric Supply	250,000	...	10 0 0	...	...
St. James's Electric Light, Limited	50,000	50,000	5 0 0	2 0 0	20,000
Union Electrical Power and Light, Limited	500,000	125,000	5 0 0	2 0 0	50,000
Winfields, Limited	160,000	120,000	5 0 0	3 0 0	72,000
Woodhouse and Rawson, Limited	200,000	105,000	5 0 0	1 0 0	21,000

CITY NOTES.

German Union Trust.—The directors have declared an interim dividend of 5s. 9d. per share.

Eastern Extension Company.—The interest of this company's Six per Cent. Debentures, due February 1, will be paid at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons must be left three clear days for examination.

Direct United States Cable Company.—The report of the Direct United States Cable Company for the six months ended the 31st December states that the revenue (subject to revision on settlement with the French Company), after deducting out-payments, amounted to £23,003, against £19,603 (after similar deductions) for the corresponding period of 1886. The working and other expenses, including income-tax, &c., amounted to £15,865, leaving a balance of £7,138 as the net profit, making, with £5,004 transferred from the reserve fund account, a total of £12,142. For the corresponding half-year of 1886 the working expenses and other payments amounted to £16,354. Interim dividends of 2s. per share each for the quarters ended the 30th September and the 31st December, together amounting to £12,142, have been declared.

Eastern Telegraph Company.—The directors of the Eastern Telegraph Company (Limited) in their report for the half-year ending the 30th of September state that the revenue amounted to £291,265, from which are deducted £79,936 for the ordinary expenses and £34,102 for expenditure relating to repairs and renewals of cables, &c. After providing for income-tax, there remains a balance of £172,761, to which is added £559 brought forward. From the available balance there have been paid—Interest on debentures and debenture stock, £28,538; dividend on preference shares, £20,384; and two interim dividends of 1¼ per cent. each on the ordinary shares, £95,000, leaving £29,398 to be carried forward. The directors have satisfactorily completed the issue of 4 per cent. mortgage debenture stock to replace the £450,000 5 per cent. debentures which fell due on August 1st last.—The ordinary meeting was held yesterday.

NOTES.

Subaqueous Illuminations.—In the experiments made at New York with a submerged 100-candle incandescence lamp, objects at a distance of 148ft. from the lamp were, it is said, rendered visible.

North Shields.—The covered market for North Shields was opened last week by the Mayor of Tynemouth. This market is another example of modern innovation, it being lit by means of the electric light.

Lighting of Messrs. W. H. Smith and Son's.—We understand that Messrs. Woodhouse and Rawson have been entrusted with the wiring of Messrs. W. H. Smith and Sons's extensive premises in the Strand, in order that the offices may be lighted by electricity.

Torquay.—We are glad to see that the use of the electric light is extending to provincial theatres. At the Torquay Theatre the flies of the stage are lighted by electricity, and this method of illumination is utilised in some of the spectacular scenes of a play now running.

Amiens.—The Société Industrielle of Amiens offers a prize for the best electric light installation in a factory. The installation must be equivalent to 300 gas jets, and cheaper than gas made on the premises. The plans and description of the installation must be sent in to the Society before the last day of April.

Copper.—The Paris correspondent of the *Times* has given his explanation about the present copper "boom." It arose, according to this account, from a speculation of the Société des Métaux, which, finding itself and friends loaded with a large amount of Rio Tinto shares, was compelled to go on buying and bargaining.

Solution for the Electro-deposition of Aluminium.—According to the recipe of M. Hermann Reinbold, 50 parts by weight of alum (?ammonia alum) are dissolved in 300 parts of water, 10 parts of aluminic chloride are then added, and the solution is heated to 200deg. Fah. After cooling, 39 parts of potassic cyanide are added. A plate of aluminium constitutes the anode, and the current employed must be weak.

Electro-deposition of Metals by means of the Disruptive Discharge.—Mr. R. K. Boyte, according to the *Scientific American*, has devised a process for coating objects with a layer of any given metal by a dry method of electro-deposition. The object to be coated is covered with a sheet of the metal which is to furnish the deposit, and an intermittent discharge—it is not stated from what source nor in which direction—is passed between them.

Odium Medicum.—Dr. T. Wilson, taking part in this controversy, which has been lately raging in *The Times*, asks, as part of his argument:—Who can explain why a powerful horseshoe magnet can magnetise a bar of steel and lose no power, in fact improve by the operation? One may continue to magnetise steel with the same horseshoe magnet for ever and ever, until all the steel in the world becomes magnetic, and still the magnet remains as lively as ever.

High Jinks.—At a conversazione and concert, held at the Edison and Swan Company's works, Ponder's End, nearly the whole of the employés accepted the invitation of the manager, Mr. Gimingham, to whose kindness the entertainment was due. The musical section of the employés volunteered their services, and a pleasing programme was provided, the performances being much appreciated. The entire arrangements were carried out in a highly satisfactory manner.

Watt-hours or Watts-hour.—We notice that some of our esteemed *confrères d'outre Manche* employ, as the plural of *watt-heure*, the expression *watts-heure*. Surely this is a mistake! The unit of work in question, in the plural, might just as well be hour-watts as the converse. It is the compound word that is in the plural, not either of its components. The expression we refer to would convey the impression that the numerical value was dependent upon, and equal to, the number of watts only—the unit of time being taken in the singular.

Conical Electro-Magnets.—In the case of a cylindrical electro-magnet, the magnetic attraction becomes nil at a distance from the pole greater than half the length of the magnet. But if the core and its surrounding coil are of conical form, the distance of attraction, measured from the smaller end of the core, may extend to two-thirds the length of the magnet. According to *l'Electricien*, M. Th. Burger, who has recently taken out a patent in Germany for electro-magnets of this form, recommends the use of a double magnet, *i.e.* two conical magnets, one fitted within the other, and having their similar poles at the same end.

New Carbons for Arc Lamps.—Mr. Gime as devised a new process of preparing carbons for arc lamps, which it is said give good results. These carbons are made as follows: Equal parts of close-burning coal and very pure coke are triturated together, and to them is added a sufficient quantity of water saturated with boric acid to make a plastic paste, which latter is passed through moulds under a pressure of from 75 to 100 atmospheres. The rods obtained are cut to the proper length, put into a furnace, and raised to a bright red heat. A single baking produces very dense and hard carbons.

Electric Traction.—According to the *Telegraph*, the Metropolitan Railway Company have concluded an arrangement with the Electric Traction Company for the experimental running upon a section of the line outside the circle of an electric locomotive of the same power as the present steam locomotive. The Traction Company stipulate that should the experiment prove an advantageous and economical method of working they are to have the option of entering into an agreement for working the railway by electricity for a term of five years, at a rate per train-mile to be agreed upon, such rate not to be in excess of the cost of working by means of steam locomotives.

Soldering Telegraph and other Conducting Wires.—With a view to save expenditure of time in cleaning the rusty ends of wires to be soldered together, Mr. Prisiajusky, in an American contemporary, makes a suggestion which strikes us as not being altogether novel on this side of the Atlantic. A quantity of solder is melted in an iron pot, and fragments of sal-ammoniac, which become melted, are thrown upon it. The ends of the wires are first dipped into the fused salt (which has the property of dissolving most of the metallic oxides), and afterwards into the solder, being in the latter case held together by binding wire or other suitable means. Should the solder not adhere on the first trial, the operation is to be repeated.

Electric Lighting in the City.—At a meeting of the City Commissioners of Sewers on Tuesday, Mr. J. S. Bell brought up the report of the Streets Committee, which contained an amended arrangement with the Anglo-

American Brush Electric Light Corporation for lighting a district of the City by electricity. Mr. Bell said he was sorry to see that so many of the members had left the court when a question of such importance was to be considered.—Mr. Shaw thought the subject was far too important to be settled at the fag end of the meeting, when many members who desired to take part in the discussion had left.—Ultimately it was agreed that the matter of the report be printed and circulated among the members, and that it should be considered at an early hour at the next meeting of the court.

Madrid.—Fourteen petitions have been presented to the municipality of Madrid to use the public throughfares for laying cables for the supply of electric light and power; but, in the unbusiness-like manner in which such things are dealt with by the local authority, no decision has been come to, and it is difficult to say when there will be one. In the meantime a very badly managed company, who have a provisional authority to lay cables, is supplying about 1,000 incandescent lights and some 80 arcs. On the other hand, the Madrid Gas Company pretend that they alone have the right to lay underground cables for electric light. In fact, everything relating to distribution is in such a state of chaos that even primary batteries would have a chance of adoption if their working expenses could be brought down to a point at which the cost would be about equal to 8s. per 1,000ft. for gas.

The Proposed Pacific Cable.—A special dispatch from Ottawa, Ontario, to the Boston *Herald*, under date of December 27, read as follows:—Your correspondent learned at the Department of Marine and Fisheries to-day that, owing to some misunderstanding between the Dominion and Australian Governments, the departure of the Dominion Government steamer "Alert," which was to have left Halifax this month for the Pacific, to make a survey from British Columbia to Australia, for the proposed cable, has been indefinitely postponed. The two Governments were to carry on the survey jointly, the Dominion Government to furnish the steamer and Australia to defray expenses. Every arrangement had been made for the "Alert's" departure, and the delay has caused much disappointment to the projectors. The cable was to form part of the Fleming system, by which he proposed to connect British Columbia, Australia, and India, and in which he has been promised the support of all the Governments concerned.

Telephone Switch Board.—The largest of these boards at present existing is at the New York Exchange. This board is subdivided into 44 sections, and is placed on the top floor of the building. It will accommodate 6,000 wires, with capacity for increasing to 10,000 when wanted. This mammoth board will be nearly 300ft. long, running through each wing of the building, and across the front. To make the connections in the office, over 1,000,000 joints had to be soldered in the wires, and about 3,000 miles of wire have been used. There will be an operator for each 50 subscribers, and each operator will be provided with the most advanced improvements in telephone transmitters and head receivers. The batteries are all under the floor of the room, where they can be readily reached, to ensure proper care, and every other possible provision has been made to secure as nearly a model service as can be obtained at this time. Some idea of the tremendons size of the board may be gathered when it is stated that 110 men were constantly employed for two months, and a large number for several months, in the construction of it.

Overhead Wires in London.—The opposition of the local authorities to overhead wires in and around London, which in 1885 led to the withdrawal of the bill introduced by the United Telephone Company, is likely to be renewed this session through the depositing of a bill by the same company to carry out in a more limited area the powers originally proposed in 1885. The main object of the bill is to obtain Parliamentary sanction to the erection of overhead telephonic wires along any road or land within the city of London, the county of Middlesex, and so much of the counties of Surrey, Kent, and Herts, as lie within 12 miles of the General Post Office. For this purpose powers are sought to place and maintain posts along any roadway upon giving 21 days' notice to the local authorities; and over any lands, with the consent of the occupier, lessee, or owner. By the bill of 1885, it was intended that these powers should extend to 100 miles of the General Post Office, instead of 12 as now proposed. These powers are asked for, we suppose, in order to enable trunk lines to be erected, to connect London with other industrial centres.

Primary Batteries.—Mr. C. R. Alder Wright has made experiments in the construction of batteries in which platinum or carbon plates are immersed in communicating fluids capable of undergoing chemical reaction. In all cases the plate immersed in the oxidisable fluid acquires the lower potential, the other the higher potential. The liquids are prevented from mixing by the interposition of some other liquid, through which the two must diffuse, the intermediate reagent being placed in the bend of a U-tube, the limbs of which contain the other two, or in a beaker placed between two beakers containing the others, and communicating with them by cotton or asbestos wicks. Among the liquids mentioned are:—(A) Solution of sulphurous acid opposed to potassium chromate and sulphuric acid solution, with sulphuric acid intermediate; this cell developes about 1·5 volt, and is constant. (B) Sodium sulphite solution opposed to potassium permanganate rendered alkaline with potassium hydroxide. (C) Chromium sesquioxide dissolved in sodium hydroxide, opposed to potassium bichromate and sulphuric acid solution. (D) Potassium ferrocyanide opposed to potassium bichromate and sulphuric acid. (E) Lead oxide dissolved in sodium hydroxide, opposed to alkaline permanganate, hypochlorite or hypobromite.

"Toy Telephones."—Two amusing stipulations were filed in the United States Circuit Court yesterday by the defendants in the case of the American Bell Telephone Company against A. S. Aloe and others. Last August the Bell Telephone Company commenced a legal war on all parties having in their possession, making, selling, buying, or using electrical apparatus similar to those made and used by that company, and for which it had letters patent. In answer to the charge Mr. Aloe said he acknowledged the letters patent and had made no attempt to infringe. While in Paris a few years ago he bought three toy telephones, which he afterwards used in his store. He sold a set of them to a party unknown to him, not knowing that the same was an infringement. He destroyed his set of toy telephones as soon as he heard he was infringing, and promises not to make or sell any more. He asks that the case be dismissed at his cost. As to William Grady, his chief clerk, charged with in the case, he says he reprimanded him and told him not to abuse his position. Mr. William Grady, the "et al" in the case,

says he admits the validity of the patents and did not use any other than the Pan telephone, and he promises not to use, make, sell, buy or procure any telephone but the Bell. This statement, he concludes, is made voluntarily, at the request of the Bell Telephone Company.—*St. Louis Republican.*

Testing Dynamos.—M. Hummel, in the *Electrotechnische Zeitschrift*, suggested a modification of Cardew's plan of testing dynamos, the following abstract of which is from the Institution of Civil Engineers' *Journal*:—"In certain cases the approximate total efficiency of two dynamos can be readily determined by Cardew's method, which is, however, inapplicable to the testing of a single machine. With the author's arrangement the energy absorbed by any given machine is deduced from the electrical measurements of a dynamo, which may be called the standard machine, or D_1. The output of this standard, with any definite current strength and potential that may be decided upon, and at a certain number of revolutions, is obtained beforehand by means of a brake. The measurements were made in two series. In the first, the current strength was maintained constant, whilst the speed and potential varied within wide limits; in the second, the speed was kept uniform, and the current and potential altered. The load on the brake during each test was changed according to the output. Curves representing the results obtained were plotted out, so that the amount of mechanical work available at the axle of the standard dynamo is at once known, or can be readily computed by means of a simple interpolation whenever the current strength, potential and number of revolutions of the machine are at hand. This graphical representation of the working conditions of D_1 has also been utilised to determine the energy absorbed by various experimental machines, shafting, gearing, &c., as well as the loss due to currents in different rings for Schuckert's machines, and in the armature discs, &c."

Electric Telegraph in China.—A feat in the suspension of telegraph wires, says the *Engineer*, has just been accomplished in the Celestial Empire, which, we believe, has been surpassed but in a single instance only. The river Luang, in the province of Chih Li of that country, had to be crossed. This river when at flood is ten miles broad; but it is at all times a wide and rapid stream, running between precipitous banks. The cables at first laid down were completely destroyed by the force of the stream, and it was found impossible to establish communication by their means. A *détour* of twenty miles discovered a possible crossing place for aerial wires. A cable of steel wire was specially made by Messrs. Siemens, of London, composed of seven strands, each 0·145in. in diameter. This cable weighed 6½ tons, and had a breaking strain of 15,000lb. To reach its destination it had to be carried in carts over 130 miles of very rough and mountainous country. When erected its horizontal span was 4,648ft., the height of the two supports being 447ft. and 737ft. respectively above the river bed. As it now hangs, the vertex of the curve of suspension is 78ft. above water level. The work of erection has been carried out by Mr. A. de Linde, a Danish engineer, under the direction of Mr. C. Poalsen, assistant-director of the Chinese Government telegraphs. The sole instance of a greater existing span referred to above is one over the River Kistna at Bezarrah, in the Madras Presidency, the span of which is 5,070ft. The work of telegraph extension in China, after it leaves the vast alluvial plains of that country, is evidently one involving the exercise of high engineering skill.

An Electric Birch.—"The latest advance in applied science hails," says the *Private Schoolmaster*, "from La Belle France. A French schoolmaster has freed himself from the trammels of conventionalism, and added a new chapter to the history of flagellation by inventing an electric birch. Electric birch, forsooth! We have heard of many strange things that have come out of electricity, but anything so scientifically illustrative of the *argumentum ad hominem* or *ad baculum* we have, indeed, never heard of before. There are, however, two properties of this electric birch that do not belong to the bundle of birchen twigs, heretofore orthodox; and in themselves they have certain claims to superiority. By the employment of electric punition, no mark or sign is left upon the skin, to the disgrace of the boy whose schoolfellows may know of such a souvenir of a *mauvais quart d'heure*, or to his discomfort should he desire to sit down. Again, by the use of easily-adjusted machinery, the force of the blows can be regulated to a nicety throughout their infliction. This is a boon to the boy, for it is a protection from the master, who may be a bad tempered man, and warm to his work as he proceeds. But we fear that the ingenious pedagogue who devised this electric birch is not destined to realise a fortune by his invention. Were we once to accede to the offers, however liberal, that science may make us in the matter of flagellants, there would loom before us a whole machinery of terror, in comparison with which the racks and screws of the Inquisition and the formidable fasces of the Roman lictors would pale."

Electrical Distribution of Time.—Many attempts have been made in past years to solve the problem of causing the pendulums of different clocks to vibrate in unison with each other by means of an electrical current periodically transmitted from a central station; but hitherto inventors have not succeeded in obtaining perfect synchronism. In a paper recently read before the Paris Académie des Sciences, M. Cornu has returned to the subject and shown analytically that to obtain synchronism in a vibrating system, the necessary and sufficient condition is that the free motion of the system shall be a damped vibration, and has also pointed out that the stable condition is obtained more rapidly the greater the amount of the damping. To carry out this in practice, it is necessary, if two pendulums are to vibrate, that they should synchronously experience an impulse in one direction, and a retardation in the opposite sense in rigorously the same way. This M. Cornu obtains by fixing a permanent magnet to the lower extremity of the pendulum, the magnetic axis being perpendicular to the axis of the pendulum. An electro-magnet, with an open circuit, is fixed on one side of the pendulum and attracts it at each oscillation. On the other side is placed another electro-magnet, with a closed circuit, which acts simply as a damper and checks each swing. In this way perfect synchronism can be obtained between clocks a very considerable distance apart, which, indeed, is only limited by the length of line at which the retardation of the current from self-induction becomes sensible. Clocks constructed on this principle for the Geographical Department of the French War Office have been successfully synchronised over a distance of forty miles of a defective telegraph line.—*Engineering.*

Dangers of Overhead Electric Wires.—In New York recently people passing along the east side of Union Square about nine o'clock in the evening were attracted to a small but brilliant pyrotechnic display made by one of the telephone wires crossing Fourth Avenue at Fourteenth

Street. Suddenly a spark larger and more brilliant than any of the others flew from the wire, and a team of horses drawing car No. 137 of the Fourth Avenue line, which was passing under the wire at the time on the uptown track, began to dance and prance about. One of the horses the next moment dropped to the pavement as though it had been shot, and the driver noticed that the thin telephone wire was broken and wound round the animals legs and neck. He jumped from the car and was about to tear the wire from his horse's neck, when Officer Kaieser, who happened to see the occurrence, held him back. It was then discovered that the horse which had fallen was dead, and the deadly character in the broken wire thus being demonstrated, there was a lively scattering of the crowd in all directions. Officers Kaieser and Hass succeeded in taking the harness from the live horse, and saved it from the fate of its mate. Travel was delayed on the Fourth Avenue line for over a half hour. Finally a man came along with a ladder, and a huge pair of rubber gloves on his hands. He climbed the ladder, which the policeman held as far from the dead horse as possible, and cut the wires. The circuit was thus broken and the danger removed. The horse was quickly hauled from the track and travel resumed. The accident was caused by the telephone wire falling upon the electric light wire, and becoming impregnated with the strong current of the latter.—*Scientific American.*

Pepys' Electric Furnace.—Prof. Houston, writing in the *Journal* of the Franklin Institute, points out that the idea of utilising powerful electric currents for performing such metallurgical operations as require a high and yet readily regulable temperature is quite old. He purposes giving brief descriptions of the early applications of electricity to furnace operations, and goes on to describe the work of Pepys which was connected with and directed to the establishing the identity of the diamond and carbon. The apparatus devised for the purpose constitutes one of the earliest electric furnaces. Mr. Pepys bent a wire of pure soft iron, so as to form an angle in the middle, in which part he divided it longitudinally by a fine saw. In the opening so formed he placed diamond powder, securing it in its situation by two finer wires laid above and below it, and kept from shifting by another small wire bound firmly and closely around them. All the wires were of pure soft iron, and the part containing the diamond powder was enveloped by thin leaves of talc. Thus arranged the apparatus was placed in the electrical circuit, where it soon became red hot and was kept so for six minutes. The ignition was so far from intense that few who witnessed the experiment expected any decided result. On opening the wire, however, Mr. Pepys found that the whole of the diamond had disappeared; the interior surface of the iron had fused into numerous cavities, notwithstanding the very moderate heat to which it had been exposed, and all that part which had been in contact with the diamond was converted into perfect blistered steel—a portion of it being heated red, and plunged into water, became so hard as to resist the file and to scratch glass. As will be seen the above is an excellent description of an electric furnace pure and simple. Bearing in mind the date of the publication it shows very considerable ingenuity.

"Journal of Gas Lighting."—Perhaps one of the most wonderful operations in modern scientific literature has been the compulsory acknowledgement of the *Journal of Gas Lighting* that there was any future for electric lighting. In the current issue, after dealing with our criticism on the *Morning Post*, our contemporary concludes its usual weekly article with the following paragraph :—"There is an electric lighting installation at Kensington Court, which at the present time supplies about 1,000 incandescent lamps in private houses in the neighbourhood of Kensington and Chelsea. This venture is under the control of Messrs. Crompton and Co., who anticipate a large increase of business in the locality, and say they have room at the station for plant to supply 20,000 lamps. The charge is after the rate of 0·28d. per hour per lamp, or 8d. per Board of Trade unit, or 6s. 8d. per 1,000 cubic feet for equivalent gas lighting, which does not appear to frighten the dwellers in this well-to-do neighbourhood. It seems probable that the year will witness a decided extension of these small lighting stations in the City of London and some of the richer suburbs. The idea in favour for the moment is for the owner of a large house or suite of offices to put down larger generating plant than he needs for his own premises (which does not greatly increase his capital outlay), and then to supply a select coterie of neighbours. This arrangement pleases both parties, presuming that they like electric lighting. It causes no more work to look after a 2,000-light plant than after one of half the power; and the rental to the outside consumers can be fixed at a price to return a little profit to the man who has the the trouble of the machinery. The insurance offices are in possession of a number of proposals of this character, and have not quite settled what rate to charge for the extra risk. It is, of course, easy to exaggerate the significance of this movement. But there can be no doubt of its reality; and it must be noted as one of the signs of the times."

Sunstroke by Electricity.—Dr. Defontaine, the medical officer attached to the famous French foundry at Creuzot, recently communicated to the Surgical Society of Paris some observations on sunstroke by electricity. The phrase seems a misnomer, but none the less what Dr. Defontaine describes seem to be veritable cases of sunstroke. At Creuzot, electricity is employed in the form of an intense focus to smelt certain minerals, as well as to melt and solder metals. A metal placed in the electric arc is fused as if by magic, steel melting in a few seconds. The electric arc in which metals are soldered is of marvellous radiance, its luminosity focussed upon a few square inches exceeding 10,000 carcel lamps and surpassing 100,000 candles. Although persons standing near this glow feel no heat they become conscious of acute pain, and for an hour or two afterwards those who have been within ten yards of this intense radiance experience a burning sensation, with more or less pain in the neck, face, and forehead, their skin at the same time assuming a coppery-red tint. Although it is customary to protect spectators' eyes with blackened sun-glasses, the retina is affected to such an extent that blindness supervenes in broad daylight for several minutes, and for nearly an hour all objects are seen in a deep saffron colour. There is irritation of the conjunctiva, and the congestion lasts 48 hours at least, accompanied by a sense of gritty particles inside the eyelids. The lachrymal glands suffer excessive stimulation and tears flow, while other symptoms are sleeplessness and headache. In ordinary sunstroke it is customary to attribute the illness produced to the heat, because in that case the solar heat is felt. But in the case of electricity there is no heightened temperature, a thermometer placed within five yards of the electric arc that is melting steel like butter scarcely being affected, so intensely is the heat concentrated. But while the thermometer is unaffected by close contiguity, persons standing

fourteen yards away suffer from stroke, proving very conclusively that it is the light and not the heat which is the cause of the mischief.

Vienna.—The Vienna Society of Electricians appointed some time ago a committee to draw up rules and regulations for the public supply of electricity, which will be submitted to Parliament with a view to obtain a kind of Electric Lighting Act for Austria. The committee have finished their labours, and their report will be laid before the members at the next general meeting of the Society. It will then be discussed, and, if necessary, amended, after which the Society will finally adopt and recommend it as the basis of a Bill to be introduced in the next session of Parliament.—Messrs. Czeija and Nissl, of this town, have just brought out a new search light, which has been specially designed for use on torpedo boats. The lamp is self-feeding and works perfectly well, not only when placed vertically, but even when inclined to an angle of 65deg. from the vertical.—The Allgemeine Elektrizitäts Gesellschaft, of Berlin, is now establishing a branch at Vienna. The company has commenced negotiations with the Imperial Continental Gas Association, with a view to taking over their electric light works in the Schenkenstrasse, and the installation at the Vienna Opera House. This company will also be represented at the forthcoming Exhibition in the Prater by an installation of 90 arcs and 1,500 glow lamps, lighting the park to the west of the Rotunda, and a portion of the interior of the latter. The rest of the lighting will be divided between the following firms; Siemens & Halske, of Vienna; Egger & Co., Kremendky; Mayer & Co., Krizik; Ganz & Co., and Brueckner, Ross & Co., who will instal an aggregate of 180 arcs and 2,000 glow lamps. As in 1883, a special feature of the exhibition will be model rooms furnished in various styles, and lighted by glow lamps, for which purpose about 750 lamps will be required. In the Emperor's pavilion there will be 100 glow lamps. Generally speaking the electric light will be installed not as an exhibit, but with a view to produce the best illumination of the other exhibits. The total motive power required is estimated at 600 h.-p. There will be telephonic communication by means of Fostin-Herrman underground cables between the Vienna Opera and the Rotunda.—*Industries.*

Accumulators for Electric Light Installation.—We have to obtain the *constants* of the lamps in normal working: amperes, volts at the terminals, watts utilised in the lamps, the maximum number of lamps to be worked at the same time, and the total extent of the lighting to be directly effected by the accumulators, expressed in watt-hours. We will suppose, as an example, an installation of 20 lamps of 10 candles, each taking 1 ampere and 30 volts, or 30 watts. A maximum of 10 lamps is to be worked at the same time, and the daily amount of lighting is about 8 lamps during 5 hours, or 40 lamp hours, or $40 \times 30 = 1,200$ watt-hours; the maximum power to be supplied being $10 \times 30 = 300$ watts. We must examine successively the two conditions to be fulfilled to satisfy the requirements of duration and maximum rate of working. Let us adopt, for instance, an average type of accumulator cell having a useful E.M.F. of 2 volts, storing 10 ampere hours per kilo of plates, capable of supplying from 1·5 to 2 amperes per kilo, and costing 3 francs per kilo. This accumulator can give 20 watt-hours per kilo of plates, and can work at the rate of 3 watts per kilo. To supply the 1,200 watt-hours requisite for the period of lighting 60 kilos of plates would suffice; but 100 kilos are necessary to keep 10 lamps working at once without running too close to the maximum rate of working. The installation will therefore require 100 kilos of plates, costing 300 francs. The selection of the type to be adoped will be suggested by the character of the installation itself. In the particular case before us, 16 or 17 cells must be arranged in series, in order to secure the 30 volts necessary for working each lamp. If the plates in each cell weigh 6 kilo, the capacity will be 60 ampere-hours, which is amply sufficient, since 40 ampere-hours only are required. And the maximum rate of supply obtainable is 12 amperes, which is in excess of the quantity required for the ten lamps working at once. If it be desired to charge the accumulators once only in n days, each cell must weigh n times as much as above. In the accumulator we have taken as a type the expenditure for the means of obtaining each useful watt is about 1 franc, and the expenditure for the supply of each watt-hour is about 15 centimes. Thus, for each horse-power hour (736 watt-hours) we require to expend in accumulators $736 \times 0·15 = 110$ francs. But the cost for each electrical horse-power available is $1 \times 736 = 736$ francs.—*Hospitalier's Formulaire Pratique.*

Gas or Ghastliness.—Our contemporary *Money* makes a merry spluttering over the proposed lighting in the City. Surely the acme of conceited infallibility is reached by the writer of the following elegantly critical lines:—"If the British public, and the metropolitan British public in particular, do not keep their eyes very wide open they will shortly be 'nobbled' by some of the Yankee or other electric light vending fraternity. Foreigners, as a rule, do not come over here for our benefit, and for the last six or seven years first one set of adventurers and then another have been trying all they knew to wheedle, coax, or frighten the holders of gas shares into parting with their property at any price they could get, and inducing them to invest, or rather sink, the proceeds in one form or other of that sickly, spluttering, flickering, deceiving, costly, dangerous, and uncertain thing called the electric light, but which for purposes of practical utility remains almost what it was when first introduced, namely, a scientific toy wherewith to terrify nervous shareholders. And yet, though little or nothing has been done to surmount the great, if not insuperable, difficulties we pointed out several years ago—an exposition which restored the depressed gas shares, then fallen to the alarming figure of about 140, to nearly 200—'we hear,' and 'it is rumoured,' and 'one says' that the old familiar bogey is about to be trotted out again, as though it had not been thoroughly exposed and discredited, both theoretically and practically, over and over again. This time it is said to be Brush-light (not rushlight), respecting which negotiations have long been pending, and upon which the City Fathers are to be persuaded to risk a very large sum of money—far more than the cost of good gaslight—and also to risk something more important still, viz., the safety of the metropolis during the recurrence of those fitful, alarming, and entirely unforetold visitations of sudden darkness that have repeatedly occurred in the House of Parliament and other places where the electric lighters have unfortunately for a time been allowed to have the control of the illuminating arrangements. Crowded as we know that some quarters of London are with hundreds or thousands of native and foreign thieves, roughs, dynamiters, murderers, socialists, anarchists, and the predatory classes of all kinds, the very thought of London being handed over to their tender mercies for even a single night of utter darkness is enough to fill the mind with horror."

SOME POINTS IN THE MECHANICAL CONSTRUCTION OF DYNAMOS.

A great deal has been said and written about those improvements in dynamo design, which might properly be described as electrical, including of course the more efficient arrangement and configuration of the magnetic circuit, prevention of injurious heating, avoidance, or at least reduction, of self-induction, suppression of sparking, and many similar points; but speakers and writers on the subject generally dismiss the question of purely mechanical construction with a few sentences to the effect that the machine should be throughout well and substantially constructed. Such a recommendation might almost seem superfluous if addressed to the designers of dynamos who, by previous experience, including occasional failures of their machines from purely mechanical defects, may be trusted to have now acquired sufficient practical knowledge of the subject; but if addressed to the user of dynamos, who is not also a designer, the recommendation is too vague to be of any practical value. The contractor who buys a dynamo to put up in one of his installations—even if he knows nothing of dynamo designing—can generally find out in a trial lasting only a few hours whether the machine he has chosen will be satisfactory from a purely electrical point of view. Sparking at the commutator can immediately be detected, the amount of self-induction in the armature coils can easily be found by comparing the electromotive force on open circuit and when supplying full current, provided the exciting power be kept the same in both cases. The limits within which the machine is self-regulating either for pressure or current are also easily ascertainable, and a six hours' run at full load will, in most cases, suffice to determine the question of heating. All this is very simple; but when we come to an examination of the mechanical points of the machine, merits or demerits are not so easily discovered. It is true that some very palpable defects, such as inefficient lubrication, insufficient bearing surfaces, want of balance in the armature, or insufficiency of running clearance, can soon be discovered. These are, however, not the only mechanical defects possible, and others of equal importance may only come to light a long time after the machine has to all appearances been successfully started. The electrical features of dynamos receive now so much attention from the makers that electrical failures have become very rare. In the early days of dynamo construction, when the armature was held together by wood, tape, and a little glue, electrical failures generally resulted from mechanical failures, but occurred sometimes also independently. The machines were badly constructed throughout, and it was often difficult to ascribe a breakdown to any particular feature of the design where every feature was bad. Now, however, the majority of failures originate from some purely mechanical defect, and generally from a defect which is not easily detected either by mere inspection or during a trial run.

It must not be forgotten that electric perfection and mechanical strength are in a certain degree antagonistic. Take, for example, the case of the armature winding. To obtain the greatest possible section of conductor, and therefore the lowest possible resistance, the whole of the available space on the surface of the armature should be utilised for the winding; but if we do this no room is left for supports or attachments by which the coils can be securely held and pushed through the field. Thus to make the armature mechanically strong we must sacrifice a part of the available space for the insertion of fastenings, and correspondingly reduce the conductivity of the armature circuit. Or, to cite another instance, to reduce self-induction and sparking it is desirable to employ a commutator with as many sections as there are coils of wire on the armature; but this is only possible in large low-tension machines. In smaller machines, and especially if wound for high tension, the number of commutator plates would become so great, and each so thin, that it would be impossible to make a strong and satisfactory job of the commutator. The matter has to be compromised by adopting a thickness of plates just sufficient for mechanical strength, and employing as many of these as can be got in with a given diameter of commutator. There is, of course, a limit to the diameter, partly on account of expense and partly on account of surface speed, which is one of the factors determining the wear of the commutator and brushes. From a purely electrical point of view it is highly important to subdivide the armature core very thoroughly. In cylinder and drum machines this can be done without difficulty; but in disc machines excessive subdivision means mechanical weakness, and here again it becomes necessary to compromise.

To the user of dynamos mechanical strength is probably of more importance than an exceptionally high efficiency. Since the average machines now in the market return from 80 to 90 per cent. of the power supplied to them, the possible margin of improvement in this respect is exceedingly narrow. A gain of, say, 5 per cent. in efficiency, although worth having, can be too dearly bought if it be accompanied by a reduction in mechanical strength. One breakdown may entail more expense and damage to the reputation of a contractor than could be compensated by the small possible saving in the annual coal bill, and we think users will rather put up with a machine of average efficiency than run the risk of failure with a machine having an abnormally high efficiency. For this reason it is probable that the present limit of efficiency, varying between 80 and 90 per cent., which experience has shown to be compatible with mechanical strength, will not be exceeded. There are, however, points in the mechanical construction of dynamos which do not in any way influence their electrical qualities, and it is to these that we would mainly call attention.

A dynamo is an exceedingly simple machine; a bed-plate, two bearings, a system of fixed magnets, and the revolving armature are all the principle parts. The armature with its commutator spindle and bearings is, indeed, the only part requiring special attention in the matter of mechanical strength, the other parts being naturally of such dimensions as enables them to easily stand the strains to which they are subjected. Now, the problem which the designer has to solve is how to get the power from the pulley (or from the crank-shaft of the steam engine if the machine be direct driven) into the armature conductors which do the work. This is usually done by making the armature core itself assist in the conveyance of power, although there are machines in the market where the wires are held by special fastenings, and the core is not subjected to mechanical strains. Either plan may be good or bad, according as it is carried out. In some machines the wire is simply wound tight over the core and held on by binding hoops. This is hardly satisfactory, as the wires must virtually be carried through the field by their friction of rest against the surface of the core. Sometimes the fastening is made more secure by little fibre pegs fitted into notches in the discs of which the core is composed, or projecting teeth are left in some of the discs against which the winding rests. Where a Pacinotti core is employed, and the winding placed within the grooves, the arrangement is mechanically perfect. The attachment of the core to the spindle is generally by hubs keyed on; but very often the length and depth of keys is utterly insufficient. We had lately occasion to examine a 20-unit dynamo having a drum armature in which only the end plates of the core were keyed to the spindle. These plates were each ⅝in. thick, and the whole bearing surface of the keys was therefore under one square inch. The machine worked apparently well; but every practical mechanic knows that in such a case a breakdown is inevitable, and is only a question of time. By degrees the metal in the key-way, or the metal of the key, but generally in both places, is squeezed away and the fastening becomes loose. To provide against such a failure the best makers of cylinder or disc machines now employ hubs extending almost throughout the whole length of the core, and fixed with long driven keys and not with a feather as formerly. In disc machines the length of the hub considerably exceeds the width of the core. Another important point in mounting the armature is the prevention of its shifting along the spindle. In disc machines this is, indeed, of vital importance, as otherwise there is danger of the armature wires rubbing against the pole pieces; and anyone who has seen the shower of sparks flying round the disc when it touches the pole pieces is not likely to forget the destructive effect of such a failure.

a in cylinder or drum machines the shifting of the e along the spindle may cause a breakdown, and to his it is wise to let one hub bear against a fixed the spindle, and to drive the keys from the other that the armature cannot come away from the collar tightening the keys. The practice of using the ator as a collar or abutment for the hubs is strongly ndemned, for the commutator can by reason of its con- never be fixed on the spindle with such certainty as tand the pounding effect of a heavy armature, should g occur from a defect in the belt or other cause, and case the armature and commutator would shift and cause end friction against the bearing. End and finally binding may also be caused by a collar on the shaft, if this be not well secured by a sunk set-screw, and especially if the thread be cut a direction that a little incipient friction will the collar. Wherever possible the thread of such hould therefore be cut right or left, according to ction of rotation. It is, however, best not to use collars at all, but to make the spindle stout enough entre to allow of turning a shoulder on it on either he distance between the shoulders should be very less than that between the bearings, to avoid end and binding if the spindle expands from heat. A own may occur from neglecting any of these but the most common source of failure is insufficient stiffness of spindle. The usual formulæ books are quite misleading if applied to the case of spindles. The reason is obvious. In most cal constructions (traction engines, steam diggers, , and a few such special machines excepted) we actly what is the limit of strains in the different parts, and can design their dimensions accordingly; a dynamo it would not be safe to only provide for ns which correspond to full output at the normal Users are very apt to overstrain their machines, ndants are apt to occasionally short circuit them elessness. We question very much whether there gle trained electrician who has not, when testing , at some time or other made a mistake in his con- , and momentarily short circuited the machine; uch a thing cannot even be avoided in the test- now is it to be avoided when the machine is hands of a man without any special training. s will happen, and it is the business of the to render them innocuous as far as possible. not advocate to build machines which can run t circuit for any length of time, but we con- machine mechanically imperfect if it will not stand omentarily short-circuited. Now, a dynamo having utput 85 per cent. efficiency will absorb on short rom five to seven times the normal power, and all ver transmitting parts must therefore be able to om five to seven times the normal working strain. of calculating the size of the spindle for the normal strain with, say, a factor of safety of six, it is y to calculate it for the abnormal strain which ome upon it when short-circuited, but in this case d not allow so high a factor of safety. As the will only under exceptional circumstances, and for hort time, be called upon to sustain the abnormal factor of from two to three will suffice. To illus- an example we shall determine the size of spindle l for a 20-unit machine running at 500 revolutions nte. The pulley would be about 18in. diameter by e, and the transmitted pull of the belt would be The strain in the tight side of the belt would be vice as much, so that the total force tending to bend ndle would be 1,380lb. The distance from the f bearing to the centre of pulley might be taken as esulting in a bending moment of 13,800 inch-pounds. sting moment is $460 \times 9 = 4{,}140$ inch-pounds. Now, ll-known formula, the moment of resistance against bined action of these forces is

$$M_r = \frac{1}{k}\left(\frac{3}{8}M_b + \frac{5}{8}\sqrt{M_b^{\,2} + M_t^{\,2}}\right)$$

M_b is the bending and M_t the twisting moment, e strain in lbs. per square inch on the outside fibres of the material. If the shaft be of steel its breaking strength might be taken as 28 tons to the square inch, and on this supposition k becomes 10,400lb. if the factor of safety is 6 for normal work, and 3,600 if the factor of safety for the short-circuit strain be taken as $2\frac{1}{2}$. The moment of resistance is determined by the diameter d of the shaft, according to the well-known formula

$$M_r = \cdot 0982\, d^3.$$

We can now calculate the diameter of the spindle by using these expressions. For the normal load the diameter comes out as 2·4in., and for the excessive load due to a short circuit the result is 3·4in. If the same power were to be absorbed by any other machine—say, for instance, by a centrifugal pump—a spindle $2\frac{7}{16}$in. in diameter, would be perfectly safe; but in a dynamo it would be insufficient. If the machine be accidentally short-circuited this spindle would be almost certain to break under the sudden strain. We are thus forced to make it about $3\frac{7}{16}$in. in the bearing.

A spindle might break not only because too thin, but also on account of its shape. A few weeks ago we had occasion to inspect a dynamo, the spindle of which had broken between the bearing and the armature in a place where failure would be least expected. The grain of the steel was perfectly sound and the area of fracture actually larger than in the centre of the bearing where the strain is naturally much larger. Insufficiency of dimension could therefore not have caused the fracture. It was evidently due to the fact that some sharp angular grooves had been turned in the spindle to throw the oil off, and although the diameter of the spindle at the bottom of the grooves was still larger than in the bearing, the continuity of the fibre of the material had evidently been spoiled by turning these grooves, and thus the fracture was started. To avoid such failures all shoulders and collars should be turned with a fairly large radius, and discs to throw off the oil should be entirely separate from the spindle.

There are many other points in connection with the mechanical construction of dynamos which merit attention, but as to deal with these would exceed the limit of space now at our disposal we must leave the further considera- tion of this subject to a future occasion.

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

(*Continued from page 57.*)

The engine which drives a dynamo is described as of so many *horse-power*, and the latter expression introduces us to the system of units employed by the mechanical engineer in estimating the quantity of work performed, and the rate of its performance. His method of measurement must be fully comprehended, for it is often necessary to measure the mechanical work expended in driving machines as well as the electrical work obtained from them. Between the mechanical units which follow and the electrical units just described there exist perfectly definite relations which must be understood and formulated before we can deal with the problems which will hereafter present themselves for solu- tion. In the equations following the student will doubtless discern a resemblance in form to those preceding.

8. *Force.*—Force may be defined as any cause which changes or tends to change the motion of a body by altering either the quantity or the direction of that motion. The engineer measures a force by the weight it will support, or by the pressure it will exert, and has chosen as his unit the force which will support a weight or exert a pressure of one pound avoirdupois, this being termed for brevity *a force of one pound.*

9. *Space, Velocity.*—The *foot* is generally adopted as the unit of space, and we may select as unit velocity *one foot per second.* A velocity of one foot per second expresses a rate of progression such that, were the motion to continue uniform for one second, the space passed over would be one foot. Calling S the feet passed over in t seconds and v the velocity in feet per second, the relation between

space and velocity, the motion being uniform, is expressed by

$$v = \frac{S}{t}.$$

10. *Work.*—Work is done when a resistance is overcome through a space. To overcome resistance force must be applied, the magnitude of the applied force being a measure of the resistance encountered. The work done is directly proportional to this force and to the space through which it is applied. It is measured by the product of force and space, the unit being the *foot-pound*, which is the work performed in lifting a weight of one pound through one foot or the work done in exerting through one foot a pressure of one pound. If 200 pounds are lifted 10 feet the work done is 200 × 10 = 2,000 foot-pounds. The same amount of work is performed if the weight is 10lb. and the space 200ft., since its quantity depending only on the product is independent of the value of the individual factors which make it up. If we call P the force exerted in pounds and F the work done in foot-pounds, then assuming that the force remains uniform

$$F = S.P$$

11. *Rate of performing work: Power.*—As in the case of electricity we require more frequently to know the rate at which electrical work is being done at the moment of observation than the quantity performed in a certain time, so the engineer more often desires to know the rate at which mechanical work is being done than to know the number of foot-pounds performed in a day or an hour. The unit rate of performing work must necessarily embrace the idea of time. Though S P gives the amount of work performed by a pressure, P, exerted through a space, S, obviously the product affords no clue to the time which the work has taken to perform, and the quantity it represents may have been produced by a man turning a handle for 10 hours, or a steam engine working for 10 seconds. Velocity in feet per second being represented by v, to obtain the rate of doing work in foot-pounds per second we have simply to multiply P by v instead of by S, the rate of performance or power at any moment being the product of force and velocity.

A rate of one foot-pound per second would be a unit too small for practical use, and accordingly a larger unit, termed the *horse-power*, of 33,000 foot-pounds per minute or 550 foot-pounds per second, has been adopted The difference between "foot-pounds" and "foot-pounds per second" should be clearly perceived, the former being a quantity, the latter simply a rate. Everyone recognises the difference between a velocity of 60 miles per hour and a distance of 60 miles, but the difference between power and work is not so readily comprehended. By a velocity of 60 miles per hour we convey the fact that were a train to move at uniform speed for one hour it would cover a distance of 60 miles, so by the term horse-power we convey the idea that were work delivered to a machine at uniform rate for one second the foot-pounds in that time would amount to 550. By a velocity of 60 miles per hour is conveyed no inference that the train will run for one hour, nor is it by the term horse-power assumed that the particular rate of one horse-power will be maintained for a second, for both velocity in the first case and power in the second may be continually varying. But we do imply by these terms that at the moment of observation a certain ratio exists between space and time in the one case and work and time in the other. In the case of a varying power, if we measure the work done in the fraction of a second, in a period of time so small that during its continuance the rate of work may be assumed uniform, and divide the work done by the time, an approximation to the rate of doing work is obtained which gets closer to the true answer as the time becomes smaller and exact when it is infinitely small. Though in a second 550 foot-pounds of work are done, it does not follow that for the whole time the work has been performed at the rate of a horse-power. In the second the power may have varied anyhow, the work at the end of the time still being 550 foot-pounds. But the power at any moment is truly expressed by the ratio of work to time as above defined. Calling H.-P. the horse-power, the relation between power, velocity, and force are given by the expression

$$\text{H.-P.} = \frac{vP}{550}.$$

If for velocity in feet per second v, we substitute velocity in feet per minute v_1, the expression becomes

$$\text{H.-P.} = \frac{v_1 P}{33{,}000}.$$

(To be continued.)

ON THE INFLUENCE OF TEMPERATURE UPON THE MAGNETISM OF IRON.*

BY M. P. LEDEBOER.

It has long been known that a magnetised bar loses its magnetic properties when heated to redness; but the temperature at which iron ceases to be a magnetic body has not hitherto been determined by direct experiment.

Many physicists have occupied themselves with these researches. Prof. Rowland (1873), who was one of the first, determined the magnetic permeability of iron in absolute measurement; this writer, experimentng up to the temperature of 230deg. (centigrade), did not observe any difference in the properties of iron. M. Poloni (1882) and Mr. McRae (1885), with temperatures reaching 280 and 300 degrees, observed only slight variations. M. Berson (1886) operated at temperatures reaching about 340 degrees. This writer showed that nickel suddenly loses its magnetic properties towards 300 degrees; in regard to iron (and cobalt) no diminution is observable at this temperature. The fact is that iron remains magnetic up to 650 degrees; and it is only at higher temperatures that a rapid variation in the magnetism is observable.

Method Employed.—We have measured the relative values of the magnetic permeability of iron by measuring the coefficient of self induction of a coil containing the bar of iron operated upon. In order to eliminate the induction due to the coil itself, a second similar coil was inserted in the opposite side of a Wheatstone's bridge; it is found that, in the absence of the bar of iron, the bridge is in equilibrium both with a continuous current, and when the extra current is brought into play. On a former occasion we showed that the quantity of electricity in the extra current is proportionate to the magnetic moment of the bar, or to the magnetic permeability.

The magnetic permeability cannot be determined in absolute measurement by experiments on a relatively short bar; for we do not know how to calculate the effect due to the extremities of the bar. Neither have we determined the residual magnetism; since this factor also is dependent upon the form of the bar. It is known that the residual magnetism is inversely as the demagnetising forces in action.

Apparatus for heating.—The bar being placed within the magnetising coil, it is necessary to heat it without raising the temperature of the latter, not only in order that the insulation may not be destroyed, but also in order that the resistance may not be varied. The production of heat is obtained by means of a spiral of platinum traversed by a voltaic current; this spiral is wound double (on a sheet of mica surrounding the iron) in order that it may not react upon the bar.†

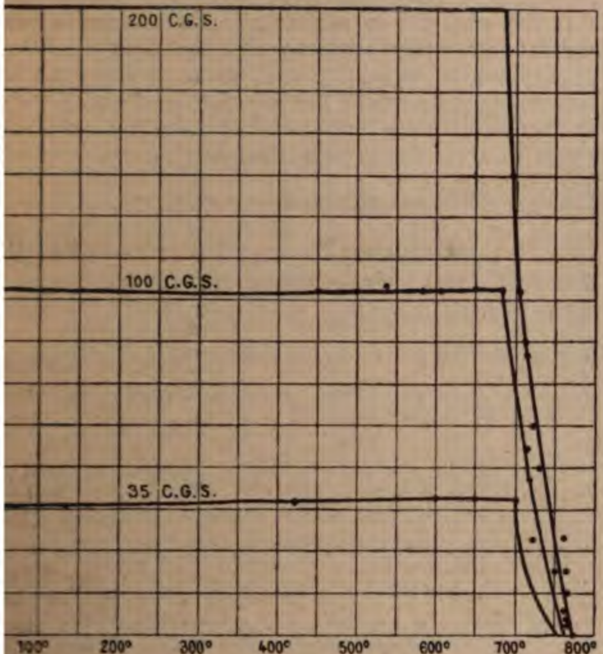
In order to measure the temperature, a thermo-electric couple of M. Le Châtelier (pure platinum and platinum-rhodium alloy) is introduced between the spiral and the iron; this couple also being insulated by means of mica. The graduation of this thermometer was taken as having been carried out at the temperatures of 100degs., of 340degs. (NH_4Cl), of 665degs. (Se), and of 1,015degs. (K_2SO_4) according to the directions of M. Le Châtelier.‡

* Note laid before the *Académie des Sciences* by M. Lippmann, Jan. 9th 1888.

† [This is somewhat obscure: what is probably meant is that there are two spirals traversed by the same current in opposite directions. Ed. *E. E.*]

‡ Le Châtelier, *Journal de Physique*, 1887; Vol. IV., p. 11.

sults obtained.—The annexed diagram shows the results ined with a bar of soft iron from Berri, subjected to netising forces of 35, 100 and 200 C.G.S. units. It will een that at temperatures below 680 degrees the iron



ins sensibly the same magnetic properties as when cold, that beyond this temperature the fall is very rapid. ards 750 degrees, these magnetic properties scarcely , and at 770 degrees they have completely disappeared. sudden variation occurs, therefore, within an interval of perature of 80 or 100 degrees. As soon as the iron is ved to cool, the magnetic properties reappear as they iously existed.

his recent researches on *the specific heat of iron at a temperature*, M. Pionchon* showed that iron undergoes ange of condition between 660 and 720 degrees ; it will een from the preceding experiments that iron loses its netic properties between 680 and 770 degrees. The ement between these figures obtained by altogether rent methods, in which the temperatures were measured by different methods, is certainly a remarkable fact.

THE LAHMEYER DYNAMO.

here has recently been brought out in Germany a amo machine which is said to give very good results,

Fig. 1.

in which the construction adopted is worthy of notice. principal idea embodied in the construction is the reduction, as much as possible, of the magnetic resistance ; and in order to accomplish this the first step taken was to adopt a construction which would permit of as little scattering of the magnetic lines of force as possible, and at the

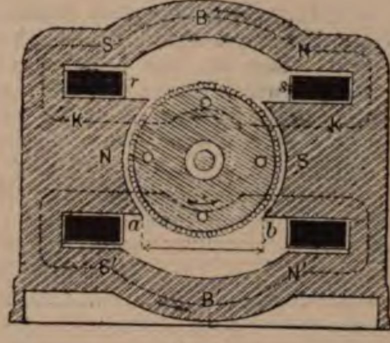


Fig. 2.

same time avoid joints in the magnetic circuit which offer more or less resistance to the magnetic flow. The machine constructed with this design in view is shown in perspective in Fig. 1, and Figs. 2 and 3 show respectively a transverse section and end view of the machine. The pole pieces,

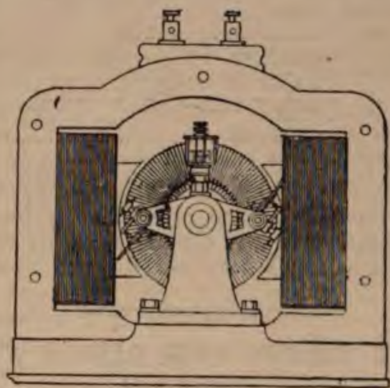


Fig 3.

which are quite short, are surrounded by coils which generate lines of force that branch out and pass over by the paths B B′ in the direction of the arrows shown. In order to avoid as much as possible the branching of the lines of force from pole to pole outside the armature, the

Fig. 4.

distance, *a b*, between the poles is made as large as possible. The whole machine, together with the base, is cast in one, so that it presents a most compact appearance. The armature of the dynamo is of the Siemens drum type, and is built up of soft iron discs insulated by thin paper washers.

Fig. 5.

At suitable intervals the plates are separated, and through these the air passes up, being admitted through the vent-holes L, at the end of the armature, shown in Figs. 4 and 5. In this way the armature is prevented from over-heat

* *Comptes rendus*, Vol. CIV., p. 135 ; 1887.

ing. In order to protect the machine from accidents by the entrance of foreign matter into the armature, a grid is placed within the arm, which is shown in Fig. 1, completely protecting the internal moving parts of the machine.

In a recent test made on this machine by Prof. W. Kohlrausch, some very interesting data regarding the construction of the same are given, which show that the average efficiency of the machine tested was over 80 per cent. The machine, which is the one illustrated, is constructed according to the following data :—

Revolutions per min.	1,200
Current	60 amp.
E.M.F.	65 volts.
Weight of machine entire	597 kg.
Weight of cast-iron	420 kg.
Length of armature drum	300 mm.
Diam. of armature discs	170 mm.
Thickness of armature discs	0·75 mm.
No. of discs	330
No. of commutator bars	38
No. of turns on armature	76
Diam. of armature wire	2·2 mm.
Current density in armature wire per sq. mm.	8·3 amp.
Weight of armature wire	2·3 kg.
Output per lb. of armature wire	1,700 watts.
Resistance of armature warm	0·112 ohm.
No. of turns in shunt field coils	2,000
Weight of shunt field coils	38·5 kg.
Diam. of wire in shunt	1·6 mm.
Resistance of wire in shunt	21 ohms.
Current in shunt	3 amp.
Current density in shunt per sq. mm.	1·5 amp.
No. turns in series field coil	25
Weight of ,, ,, ,,	9·5 kg.
Diam. ,, ,, ,,	6·5 mm.
Resistance warm series field coil	0·02 ohm.
Current density per sq. mm. in series field coil	1·8 amp.

The machine, as will be noted, is compound wound, and tests have shown that the electromotive force remains practically constant for all loads, no sparking being visible at the commutator.—*Electrical World.*

ELECTRIC ENERGY FROM CARBON WITHOUT HEAT.*

BY WILLARD E. CASE.

The following experiments, undertaken by the author, may be of interest as indicating the way in which the cheap generation of electrical energy may possibly be brought about.

In the first experiment, an element was formed through which heat energy was converted into electrical energy, in which the correlation of forces is beautifully illustrated.

It is a sort of voltaic battery, in which plates of tin and platinum forming the electrodes are immersed in a solution of chromic chloride, which has no action on the plates at ordinary temperature, so no current is generated. The cell is hermetically sealed, and when heated the liquid becomes active, and part of one of its elements, chlorine, leaves the chromic chloride, goes over and temporarily combines with the tin, forming a proto-chloride of tin. The chemical action generates an electric current, but soon the tin is all converted into chloride, and the current ceases. When the cell is cooled, this temporary combination of the chlorine and tin is broken up, and the chlorine returns to the chromium proto-chloride. The tin being set at liberty, falls as a metallic precipitate to the bottom of the cell in the form of crystals, ready to renew the combination when the cell is again heated. None of the materials of the element are destroyed; they last an infinite time. The chlorine changes from chromic chloride to tin and back, as often as the cell is heated and cooled.†

It is well known that the voltaic battery converts the potential energy of a metal directly into electricity without heat. This cell, similar to the voltaic battery, converts heat into electricity. The voltaic battery acts at ordinary temperatures, giving up all the energy stored in the metal, and there is the end of it; while this cell acts only when heat is applied to it, converting part of this heat into electricity. After the tin has all been converted into chloride the cell becomes inert, no matter how much more heat be applied. The cell must then be cooled to get this tin back into the metallic state, so here it is necessary to have a difference of temperatures, the tin and liquid being simply a medium by which heat is transformed into electric energy.

It will probably be found that the solution of the tin absorbs heat, and so tends to cool the liquid, and the precipitation develops heat, and so tends to warm the liquid, and that the part where the solution occurs must be kept warmer than that where the tin precipitates. An investigation would probably show that when electric currents are generated the heat absorbed by the solution of the tin is in excess of that generated by the precipitation by the equivalent of the electrical energy developed, and that the possible excess is governed by the second law of thermo-dynamics. If the cell works between 80deg. and 180deg. F., the E.M.F. at the higher temperature is about 0·26 volt, the efficiency is less than 16 per cent., as the possible efficiency $= \frac{T - t}{T}$ reckoned from absolute zero, or $\frac{638^\circ - 538^\circ}{638^\circ} = \cdot 157$.

In fact this cell is a heat engine, analogous to the thermopile, which is said to convert only 2 per cent. of the energy of the coal into electric energy. In practice probably nothing like 16 per cent. could be utilised.

It is an inexorable law of nature that under the conditions in which we live a great waste must accompany the transformation of heat into any other form of energy. In the condensing steam engine it requires to condense the steam four or five pounds of water to every pound of steam. Three-fourths the heat used goes to warm that water, and is wasted. In hot air engines or gas engines a cold water jacket must be used, and to it goes the larger share of the heat employed. In the thermopile one set of junctions must be kept cool by circulation of air or water. In Edison's pyromagnetic generator the iron tubes must be cooled by a blast of cold air.

By the second law of thermo-dynamics the minimum amount of heat that goes to this cooling agent is the fraction $\frac{t}{T}$ of the total amount employed, where t is the temperature of the cooler reckoned from the absolute zero and T the higher temperature of the working substance; t cannot be less than about 500deg., so the numerator of the fraction is always large, and the heat wasted is the larger portion. Understand that this is a law of nature; it is inevitable under the conditions in which we live. No cunningly devised furnace, or feed water heater, or cut-off, or triple expansion apparatus, or pyro-generator can save this heat. The most that any of these devices can do is to save what would otherwise be wasted over and above the proportion $\frac{t}{T}$. But are we to go on wasting all this energy of fuel? Cannot some means be employed to utilise it? We know that the voltaic battery is not a case of the transformation of heat into electrical energy; it produces electrical energy directly. The second law of thermo-dynamics does not apply, as no heat appears. If we could convert the chemical energy of coal and oxygen into electric energy, directly and cheaply, we would do away with all our steam motors at once. There is no known reason why a cheap substance may not be found which will act on coal and develop electric currents in place of heat. This electric energy would be the equivalent of the heat energy that would be developed by the combustion of the same coal in the ordinary way, and could be transformed into mechanical power, heat, light, &c., with small loss.

So far, little progress has been made in this direction. Some time ago Jablochkoff produced a battery in which plates of carbon and iron were immersed in fused nitre. The carbon being oxidised, furnished strong currents. The objection to this element is the generation of heat through local action. To it the second law does not apply. Another experiment of more interest than the first is an illustration of an element which is not affected by the second law, as heat is not essential to its operation. The energy due to the complete oxidation of carbon is converted into electric energy directly.

* Read before the American Institute of Electrical Engineers, January 10, 1888.

† This cell has been described in *Proc.*, Royal Society, No. 244, 1886.

In a glass cell containing sulphuric acid, C. P. Sp. Gr. 1·81, temp. 75 F., two electrodes were immersed, one of platinum, the other of lump graphite; only a slight E.M.F. was indicated, 0·007 volt, due to the combination, the graphite acting as a positive element; on the addition of a small quantity of chlorate potassium to the acid, the E.M.F. immediately rose to 00·8 volt, the graphite being disintegrated after a time. This cell polarised rapidly, which was partially prevented by mechanical means. The reaction of chlorate potassium with sulphuric acid may be represented by the following equation: 3 $KClO_3$ (chlorate of potassium) + 2H_2SO_4 (sulphuric acid) = 2 ClO_2 (peroxide of chlorine) + $KClO_4$ (perchlorate potassium) + 2 $KHSO_4$ (acid sulphate of potassium) + H_2O (water).

A method of exclusion was adopted to ascertain the oxidant of this electrolyte: chlorine peroxide (ClO_2) appeared to be the only active agent. It is decomposed by the carbon, chlorine being evolved with some oxygen. It was assumed that in this cell graphitic acid ($C_{11}H_4O_5$) was formed* as the result of the chemical actions. There is probably much waste of energy through local action, as the chemical reactions go on when the circuit is open, but to a less extent. In another experiment an electrolyte was formed of sulphuric acid and chlorine peroxide, the gas being formed in a retort by the action of sulphuric acid on chlorate potassium, and conducted over into the acid in which it was dissolved. This cell, with a positive element of graphite, opposed to platinum, gave an E.M.F. of 0·7 volt.†

A similar combination was used with a solution of chlorine peroxide in water as the electrolyte. The E.M.F. assigned to these cells is only approximate, as it was found dependent on the quantity of chlorine peroxide in solution, which was constantly changing. The resistance also varied with the different degrees of concentration of the exciting fluid.

Different forms of amorphous carbon were substituted in place of graphite in the first form of cell. Gas carbon gave an E.M.F. 0·007 volt when opposed to platinum in sulphuric acid; on the addition of chlorate potassium the E.M.F. rose to 0·5 volt.

Carbon, produced by the action of sulphuric acid on cane sugar, in this experiment gave an E.M.F. of 0·3 volt.

The carbon of animal charcoal, wood charcoal, coke, and anthracite, gave an E.M.F. variable with each form, ranging from 0·3 volt to 1·25 volt. The measurements of E.M.F. of the various combinations were made with the electrode immersed in separate parts of the same solution, that the concentration of the liquid and quantity of gas in solution might be as nearly equal in each cell as possible. It was found when the carbon in comminuted form was contained in a porous cup that the combination gave an E.M.F. of 1·24 volt, apparently due to the presence of the oxygen of the air.

It is impossible at the present stage of the investigation to assign any definite value of the E.M.F. to these forms of amorphous carbon. In some cases they appear to have an E.M.F. higher than that of graphite.

The energy of the combination of carbon and oxygen when completely oxidised to (CO_2) carbonic acid gas is stated to be 9,624· foot-pounds per grain equivalent, which is 2·0594 equivolts.‡ In these carbon elements the E.M.F. is not so high, as there must be deducted the counter E.M.F. or polarisation, and the energy due to the force of setting chlorine free.

A resort to chemical analysis, of the products formed by the reaction in the cell, indicates the following conclusions:—

1st. Carbon produced by the action of sulphuric acid on cane sugar proved to be partially oxidised, or impure carbon.

Analysis gave the following values:—

C	62·20 per cent.
H	1·61 per cent.
O	36·19 per cent.

* See *Q. Journal Chemical Soc.*, Vol. XII. October, 1859.

† Great care must be taken in the preparation of this gas, as it explodes at a temperature of about 140° F. It can be preserved in the dark, and is decomposed by sunlight into its component parts.

‡ See Sprague's *Electricity*, p. 519.

Analysis proves that (H_2SO_4 + $KClO_3$) sulphuric acid + chlorate of potassium oxidises carbonaceous bodies, like the above product of (H_2SO_4) sulphuric acid on cane sugar, to CO_2, and, further, that such bodies first are changed to compounds soluble in the acid (caramel-like substances), which are rapidly oxidised to CO_2.

2nd.—Battery carbon of the composition:—

C	96·20 per cent.
H_2O	·70 per cent.
Iron, SO_2	2·30 per cent.

The fact was shown that this form of carbon can be oxidised to CO_2.

3rd. Wood charcoal, of the following composition after ignition:—

C	94· per cent.
H_2O	5·5 per cent.
Silicious res.	·5 per cent.

This, after repeated re-ignition, was oxidised by the electrolyte to CO_2, no intermediate compounds being formed, and further, in case of pure amorphous carbon the oxidation is complete; that is, that all the carbon is oxidised to CO_2.

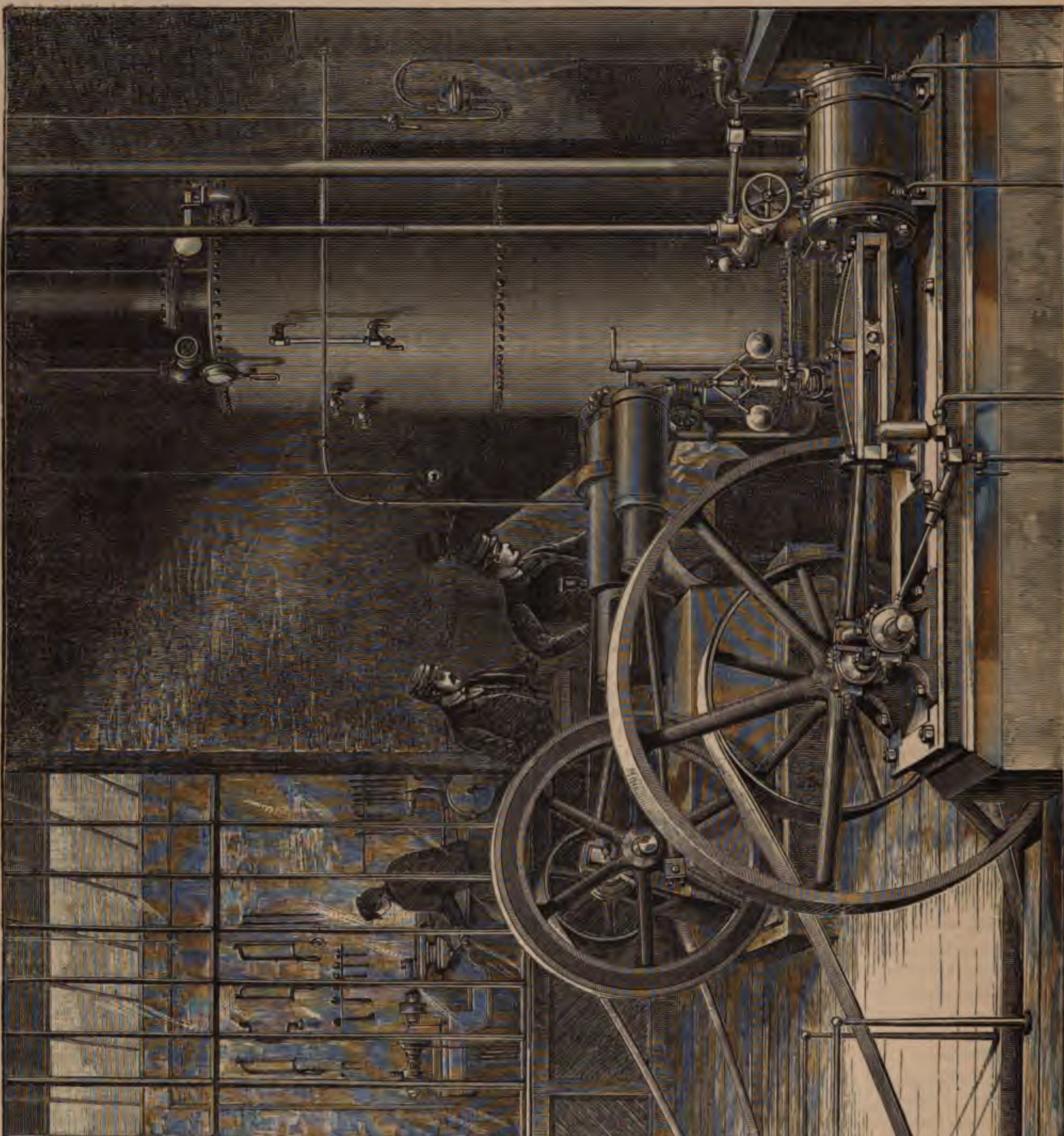
These analyses were made with the solution at a temperature of 122 F. to hasten the action, the carbon being in contact with the platinum. In these elements the oxidising material is too expensive for practical use.

Undoubtedly the direction of experiments in the future will be to find some cheap substance which will absorb oxygen from the air and give it up to the carbon; in fact, acting as a carrier of oxygen, so oxydising it without heat; and this is not improbable, as we already know of substances which do this, though giving a low E.M.F.; thus, for instance, the ferric salts are reduced to ferrous by agitating their solutions with carbon, being regenerated by absorbing oxygen from the air.

By pursuing this line of investigation we can be sure we are not ignorantly striving against any law of nature when attempting to convert the whole potential energy of carbon into electrical energy.—*Electrical World.*

THE SCHOOL OF ELECTRICAL ENGINEERING.

Many of our readers are fully acquainted with "The School" in Prince's-street, Hanover-square. A goodly number of those engaged in electrical work have passed a period of preparation therein. Instituted in years gone by—for the purpose of preparing students in the requirements of the telegraph service—it has had to change its curriculum with the altered condition of things due to the development of electric lighting. An electrical engineer is not now one familiar with the working of the Morse instrument, or of Thomson's recorder, with the testing for faults in cables, or the general manipulation of apparatus actuated by comparatively minute currents. "Other times other manners" applies to electricity as elsewhere, and unless "The School" progressed with the times it would drop out of the race and become a matter of history. In fact, in order to fill the position without adverse criticism, "The School" should be a little ahead of the time—its management and its lecturers should always be on the look out for what is in the air—and may become an actuality in the near future. That a successful effort is made to keep abreast of the times is seen from the recent addition to the "practical part" of this school. Last year a new machine room and workshop, illustrated on p. 84, were organised, and are now in full work. It will be seen that the engine-room contains both gas and steam engines. This is as it should be, for every electrical engineer should be fully acquainted with the vagaries of both kinds of engines, if their makers will concede that they have any. The teaching cannot well be too practical. The time spent in such an establishment is insufficient to permit of general education, and everything, therefore, being of a special character, should be used as a means to an end. The end aimed at is to fit the student for a position in some special branch of electrical engineering, and those best able to judge how far the curriculum is calculated to do this are those who have passed through the school and are now engaged in actual work.



ENGINE ROOM AT THE SCHOOL OF ELECTRICAL ENGINEERING.

THE

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NOTICE.

BRUSSELS EXHIBITION.

In May next this exhibition will be opened, and no doubt many English travellers will make the exhibition an excuse to visit Belgium. It has occurred to us that perhaps, either going to or from Brussels, most travellers to Belgium will visit the historic towns of Antwerp, Ghent, and Bruges. We have therefore arranged with the proprietors of the engravings to give as supplements several steel engravings illustrating Belgian scenes. These will be issued at intervals before and during the exhibition. The first of the series, issued with our current number, illustrates one of the most picturesque scenes in Ghent—the old houses at the waterside.

IN THE WAY OF BUSINESS.

There is a more or less roseate hue surrounding almost all branches of business just now, which is gratifying if for no other reason than "hope springs eternal in the human breast," and the hope is that business will continue. In our opinion there is much reason for hope so far as electrical work is concerned. Business is progressing on legitimate lines, and the speculation or the peculation which gives the deathblow to honest work, only occasionally raises its hydra head to lose it—in other words the public will not speculate. When the world was first told that gas as an illuminant was a thing of the past, that electricity would certainly supersede it in weeks if not in days, the world believed and wondered; and has gone on wondering ever since why it was so easily duped. In reality the Electric Light was ushered in as a luxury. Its development and extension was as a luxury, except perhaps in such cases when the pure light was required to aid the matching and judging of colours. In the latter case the question of expense was hardly one for consideration, and the use of the electric light in such places must not be considered when reviewing its general progress The apparatus for the generation, distribution, and measurement of electricity in 1882, when the Electric Lighting Act was passed, was crude in comparison to what it is now, and all sensible persons must acknowledge that at that time any work carried out on a large scale for general lighting would probably have been very costly, even if it had not proved a total failure. Since then successful experiments have been made. These experiments have opened our eyes to weak spots in the original systems, which weaknesses have been to a great extent remedied, and it is not too much to say that there are half-a-score of firms among us who might be trusted to successfully light a moderately-sized town with a mixture of arc and incandescent lighting.

A good deal has been said lately about central station lighting in England, but as a matter of fact we as yet have not got a single central lighting station worthy the name. The largest, that at Paddington, is a private concern to light a railway terminus. Brighton, Eastbourne, Taunton, Sheffield, &c., are none of them larger than many a private installation, nor are the difficulties their managers have to encounter equal to those which would have to be met in a case of general distribution over a whole town. The Grosvenor Gallery is often referred to as pointing out what can be done, and with this we entirely agree; it shows what can be done, but that is quite a different thing from doing it. The majority of these experiments have been successful, not because of a well thought-out scheme *ab initio*, but because of the brains superintending the operations constantly suggesting alterations and modifications to meet emergencies. Perhaps the best-considered scheme from the commencement is that at Kensington Court, but in this instance the case presented exceptional

features, and difficulties to be met with elsewhere had no existence.

We frequently meet with the statement that in England we lag behind our friends across the Atlantic and on the Continent. This statement is false and generally malicious. Although England can hardly claim the original ideas which led to the recent development of dynamos, we can confidently claim that given the ideas it is our practice that has been followed and copied on all sides. It is to England that "output" for weight, as a constant aim of designers of dynamos, is initially due. So far as the principles upon which such machines are now constructed, the world is largely indebted to Hopkinson and Kapp. But the object is not to determine the part England has taken, but merely to indicate that we dispute the attempts to take away the honour justly her due in this direction.

When we come to the adoption of arc lights for street lighting, America is far and away ahead of us, but the conditions are entirely different, and it would be surprising if the light had not been adopted in America in its earliest stages. It is singular, however, to notice that while the Americans are almost universally adopting the arc lights, the spread of incandescent lighting, and in fact the lighting of interiors generally, by no means keeps pace with the street lighting. In America the natural order of things was for street lighting to come first; in England its place was last. Private mansions, factories, railway stations, ships, and mines present a field to be worked before streets and houses, and in these directions success has been abundant. There is still an immense amount of work to be done, but every factory lighted brings us nearer the time when in such places the electric light will be the rule and not the exception. Do our business men concern themselves with the future, then look out for every hint of a new mill to be built. It is easier and cheaper to install the electric light in a new building before the gas pipes are laid than after they are laid. It is easier to arrange for twenty or forty extra horse-power when the mill boilers are being designed than after they are in position.

The modification of the Electric Lighting Act of 1882 will not mean the opening out a field of business for every firm. The large works connected with central stations mean the use of large capital, the straining of resources to the utmost, the promoting of local companies, and the finding of the "needful" till the local concerns are well afloat—conditions altogether outside the capabilities of the smaller firms. A leaf in electric lighting development may be taken from the experience, say, of the Silvertown Company or of Messrs. Siemens and others in cable work. If these companies had waited till the world came to them for cables, they would have waited a long time. It is useless, however, to enter into this business till the road is clear and unimpeded by legal obligations, which hang like millstones round the necks of those whose cry is "Forward."

Just as the conditions which hold in America relative to lighting differ from those which hold here, so do the conditions which hold with electric traction. In America the signs of the times are that electric traction will on tram-lines entirely supersede horse and steam traction, and the change is being carried out at a rapid rate.

Last week we made a suggestion to the Society; there is another we would make if it were needed. Papers have lately been read on fuses, and on measuring instruments. These might well be followed—and we believe that arrangements have been made that they should be followed—by papers on transformers and on electric traction. The capability of transformers needs discussion. Electrical engineers are at sixes and sevens on the subject; but the most important bearing is the effect of such papers on the purchasing public. The Institution of Civil Engineers has recently devoted several evenings to the discussion of electric traction, but the result of the deliberations has as yet played no part in influencing public opinion towards or against such method. "The same thing over again." Yes, decidedly. The inertia to be encountered is immense, and the impress of authority must be given to every step before the workers can hope to progress far in its application.

CABLE COMPANIES' MEETINGS.

Our reports show that within the past few days two important cable companies have held their meetings, and in both cases the shareholders were congratulated upon the results of the past half-year. The Direct United States Company, however, is not in the position of the Eastern Company, the latter declaring a good dividend, the former hoping for one. It is the duty of a chairman to keep the shareholders in a good humour, hence Sir J. Pender pointed out how nearly the Eastern Company had recovered from the blows of the Berlin Conference. The recuperative power has been shown to be great. The shareholders will have to look forward as well as backward. The action at Berlin will undoubtedly be followed up and intensified at the next Conference, and although the directors are quietly and systematically working to make their positions secure, they will need to take the shareholders more into their confidence, and to enlist the sympathies of a wider and more powerful public, if they are to hold their own. The cable companies have managed to raise up a nest of hornets about their ears at recent conferences. France bears them no good-will, and will probably bear ill-will, because of the success of the Anglo against the French Companies; for outside England there exists clanism or patriotism which sometimes interferes with reasoning, and leads those whose actions should be above suspicion to follow the dictates of financial circles. Germany is blunt and outspoken, knows her own mind, and generally manages to get what she wants. The great danger to the management of cables going eastwards is

in the action of our Australian Colonies and Canada. Will the Pacific scheme go through, or will those over whom Sir J. Pender presides take the bull by the horns and lay these cables themselves? We think they will.

LITERATURE.

Lessons in Elementary Practical Physics, by BALFOUR STEWART, M.A., F.R.S., and W.W. HALDANE GEE, B.Sc. Vol. II., "Electricity and Magnetism." [Macmillan and Co.]

Professor Fleming's lectures at Chelmsford, published in the latter part of 1886, followed by the volume by Prof. Ayrton, and by the work above mentioned, has given, so to speak, a new impetus to electrical literature of the best kind. In so progressive a subject as electricity has of recent years proved to be, the difficulty of text-books is to keep pace with the subject. The deficiencies of text-books are, however, recompensed by the technical journalism of the day, and it is necessary for the student not only to master his text books, but also to make himself conversant with the more ephemeral literature, if he would keep himself abreast of modern progress. We do not recognise as text-books that large class of books designed only with a view to assist readers in passing examinations. Nor do we recognise as students those readers whose goal is the passing of an examination. The slinger of symbols is a product of the examination mania, but the most credulous only accept the product as classed "A1 at Lloyd's." The books named have no direct connection with examinations, although the one at the head of this notice is admirably adapted for the use of masters, who can rid themselves of the trammels of calendar and syllabus. The plan adopted is to subdivide the matter "into a series of lessons, each descriptive of something to be done by a definite method with definite apparatus." We have read very carefully a large number of these lessons—there are in all 83 lessons besides appendices—and in every case have had to pronounce them good. The apparatus required during the lesson is first described, then the use of the apparatus, the phenomena shown by it, and the principles illustrated and deduced therefrom. Old Humphry in his writings dubbed the sample plums or potatoes laid carefully at the top of the basket as "toppers" and not fair representatives of the whole. The ciritic has power to select unfair samples if he chooses from any author—either super-excellent or inferior. We think an author's matter and method can best be shown by an example, and for this purpose select a portion of a fair average lesson. This lesson, XLII., is on the Use of Standard Galvanometer in the Determination of E.M.F. The authors give as the special exercise—"To find the E.M.F. in volts of a Groves cell." The apparatus required is then stated, followed by the theory of the method which results in obtaining the formula E (in volts) $= \dfrac{10\,H\,\Gamma r \tan\alpha \tan\alpha_1}{\tan\alpha - \tan\alpha_1}$. The method to be pursued in practice is then described, and an example fully worked out. The result of the example gives E = 1·76 per cell, the authors pointing out this is too low because of the presence of local iron. The last paragraph of this lesson relates to *Electro-Chemical Equivalents*, and is as follows:—When an electrolyte is placed in a galvanic circuit the amount of chemical decomposition in unit time for unit strength of current is a fixed quantity. The mass of substance liberated at the electrode is called its electro-chemical equivalent. The equivalents for certain important elements have been determined with great accuracy by Lord Rayleigh and others. Thus the amount of silver deposited from silver nitrate in one second by one ampere of current is ·001118 gramme. By the aid of this number the electro-chemical equivalent of any element can be found if we know its chemical equivalent, for if the same current be sent in succession through different electrolytes the amount of the elements deposited at the electrodes would be in the ratio of the chemical equivalents. Thus we have—

Chemical equivalent of silver = 108
" " hydrogen = 1

Hence the electro-chemical equivalent of H is

$$\frac{\cdot 001118 \times 1}{108} = \cdot 00001035.$$

Again, since the chemical equivalent of copper in the *cupric* state is $\frac{63}{2} = 31\cdot 5$, the electro-chemical equivalent is

$$\frac{\cdot 001118 \times 31\cdot 5}{108} = \cdot 000326.$$

Let W denote the mass in grammes liberated *at one electrode* by a current of strength C in t seconds, and let ϵ be the electro-chemical equivalent then we have

$$W = C\epsilon t, \text{ or } C = \frac{W}{\epsilon t}.$$

This will enable us to measure currents by ascertaining the mass in grammes liberated in a given time.

In the case of water it is customary to determine the total weight of water decomposed. Now an ampère in one second—in other words a coulomb—will liberate ·00001035 gramme of hydrogen and eight times the weight of oxygen, or ·00008280 gramme. Hence a coulomb will decompose ·00009315 gramme of water. If instead of weighing the water we measure the volume of one or both the gases liberated, it will be convenient to know the relation between the volume of these and their weight. Now 1 gramme of hydrogen measures at 0° C. and 760 mm. pressure 11170 cubic centimetres. By aid of this number it will be easy to convert the weights into volumes. The resulting values and others that are also useful are exhibited in the following table:—

TABLE I.—Electro-Chemical Equivalents.

	Grammes per coulomb.		Normal cubic centimetres per coulomb.
Hydrogen	·00001035	......	·1156
Silver..................	·001118	......	—
Copper (cupric)......	·000326	......	—
Mercury (mercuric).	·001035	......	—
Zinc	·0003364	......	—
Oxygen	·0000828	......	·0578
Water	·00009315	......	·1734

ELECTRIC TRACTION.

On Tuesday a number of gentlemen were invited to Chiswick to examine a tramcar driven by electricity. However we may desire the period to come when horse traction will be superseded by electric or other traction for tramway work, we cannot forget that a number of successful experiments have been shown in and around London, yet no progress, so far as regards actual work, can be chronicled. Inventors, if the slight modifications to existing systems warrant that title, keep pegging away to achieve success,

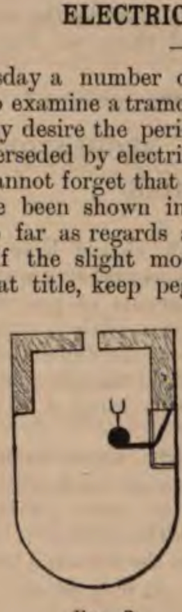


FIG. 2.

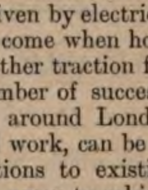


FIG. 1.

and such persistency is bound, sooner or later, to meet with its reward. It is easy to arrange a perfectly successful experiment on a scale similar to that of Tuesday. The running line was not more than 100 yards or so in length, and of course absolutely free from most of the troubles of an actual working line. The Lineff system shown is a central channel system, in which channel is carried the conductor. The improvement claimed is in the method of making contact. Let us, however, begin with the central channel, which is closed at the top, except for about ½in. through which the contact carrier passes. On the side of

the channel is a piece of wood, carrying arms at intervals, upon which the conductor rests, but insulated from the arms. The conductor is copper drawn through an iron pipe. If we may be allowed to criticise the arrangement, we might ask the value of the copper at all. At intervals of five or six feet the iron pipe is tapped, and a contact piece, Fig. 1, screwed tightly down upon the copper. Would it not be cheaper and quite as well to have a solid iron conductor into which or upon which the contact pieces could be screwed or fixed, making good contact? The conductor is some two and half inches from the vertical through the opening of the channel, and so free from likely contact with foreign substances. Of course the channel is so arranged as to be of considerable depth below the conductor, that water getting in would naturally drain off, and mud would be occasionally flushed out. (Fig. 2.)

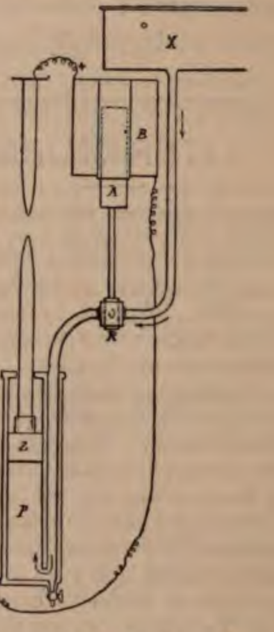
Contact is made from the car by means of a carrier through the slot into the central channel carrying a flexible rod sufficiently long to always rest upon two of the contact pieces. While the car is running all contacts will be kept bright and clean, so that no difficulty need be anticipated at this point. A street channel of the kind described will always be damp, and considerable leakage will occur if the present device is insisted upon. Surely the powers of electrical engineers are equal to so simple a demand as that of a conductor with little chance of leakage. An iron rod embedded in pitch, or some cheap insulator of that type, with only the contact pieces projecting, would give far less leakage than the form adopted. If copper is a *sine qua non*, why not put it into an abestos sheath? Water will always be formed upon, and be found dropping from the iron pipe. Why cannot some electrical engineer who really understands the first principals of the subject get "financed" by the tramways, or promotors who are eager to spend money upon crude experiments? There really seems to be no valid reason why electrical tramways should not succeed on a large scale. They *ought* to be cheaper than horseflesh, and those exponents of the system who have had some experience maintain that they are cheaper. The motor used in the experiments we have referred to is a 5 h.-p. Immisch motor, running at 1,000 revolutions when the car is going at the rate of 6½ miles per hour. The dynamo supplying the motor is also by Immisch. Some of the details of the car and the brake used are new, but to adequately describe the whole, further illustrations are necessary, and these we hope to give in another issue.

THE HYDRAULIC ARC REGULATOR OF M. BERTHIER.

This lamp, which, we think, should have preceded, in the natural order of inventions, other apparatus better adapted to the general requirements of practice, requires, it will be seen, to be in connection with a supply and discharge pipe for water. In some exceptional cases, however, this might be no objection, and, as the arrangement has the merit of simplicity, we will briefly bring it to the notice of our readers.

Referring to the diagram, the upper carbon is fixed, whilst the lower one is mounted on a piston, Z, which moves within a cylinder, P, the lower portion of which communicates by a pipe with the reservoir, X, supplying water at a certain pressure. In the tube is a tap, R, in connection with the soft iron core, A, of a solenoid, B, through which passes the current supplying the lamp.

At starting, since the core A is not attracted into the interior of the solenoid, its weight opens the tap R, and thus establishes communication between the reservoir X and the cylinder P, causing the ascent of Z, until the carbon attached to it strikes against the upper carbon. If, now, the lighting current be switched on, the water supply is stopped by the closure of R through the attraction of A into the solenoid, and in a few seconds an arc is formed between the carbon points. When the distance between the latter becomes too great, the diminution of the current brings about a flow of water through which the lower carbon is raised until the current regains its normal strength, and again causes the communication beween X and P to become closed at R. The apparatus being once properly



adjusted, a very steady light is said to be by these means obtained.

JUVENILE LECTURES.

The Royal Institution and the Society of Arts deserve the best thanks of the scientific community in that they systematically provide juvenile lectures, which are given by some of the most eminent scientific men living, generally during the Christmas holidays. This year the lectures at the Society of Arts were given by Mr. W. H. Preece, F.R.S., and were on "The Application of Electricity to Lighting and Working." The first of these lectures, which was delivered on Jannary 4th, has just been published in the society's *Journal*, and from it we take the following extracts which may probably be interesting to those who were unable to attend the lectures, and may, perhaps, not be uninteresting to older people who have not had the advantage in their earlier days of attending such lectures. With regard to the cause of illumination, Mr. Preece said:—

"In all cases of artificial illumination bodies have to be raised to a high state of temperature. I hold in my hand a piece of magnesium wire, it is really flat magnesium tape, but it is called wire. If I heat that you will observe that a very brilliant light is produced, due to the very high temperature at which it burns. Now, if I take a lump of coal and heat it—it requires to be raised to a certain temperature before the oxygen is directed upon it—and subject it to a jet of oxygen, you will see that it burns with very much more intense light than you are accustomed to in the ordinary fire. If I take a piece of iron wire and place it in a jar of oxygen, you see what a very brilliant effect the combination of oxygen and iron produces through the iron being raised to a very high temperature.

"I have now shown you that in order to produce light we must, by some means or other, raise the temperature of a body. But the high temperature that we have to deal with is not that produced by the combination of the oxygen of the air and carbon, and other bodies such as I have shown you, but it is produced by the aid of the electric current. In all these cases the result of the combustion you have seen has been to remove oxygen from the air, but now I want to show you how a body can be raised to a high state of temperature without combustion of any kind. In front of me I have a fine platinum wire. In my hand I hold a wire that is in connection with a battery upstairs, the other wire in connection with the battery is attached to the far end of the fine platinum wire; now, when I make contact with the near end of the platinum wire, you observe that the wire is raised to redness, its temperature is high, and as I reduce the length of the platinum

wire it gets brighter and brighter, the amount of electricity passing through it is greater and greater, and presently the wire is fused. I should have pointed out that as the quantity of heat generated in a wire increases, so does the colour of the light. When heat is applied to a body, that body is first warmed, then it gets gradually hotter and hotter, until it becomes red hot, and the first colour that appears is always red. The temperature is further raised, and the body assumes the colour of orange, then at a little higher temperature it appears yellow, and so the different colours of the rainbow are perceived according to the different temperatures to which the body tested with is raised. And now I want to show you the most intense form in which heat can be produced on this earth. There is no hotter object that we can obtain than that of the electric arc. I will try and produce this arc. You observe that when I bring these two pieces of carbon together a current of electricity passes between them, and the passage of the current of electricity between them creates such an intense temperature that a brilliant white light, as you see, is produced. Incandescent particles of carbon pass between the two points, forming a sort of bridge or arch, which is called the electric arc. But the temperature of this arc is, as I said before, the highest temperature that we can produce; it has been measured, and is found to be 8,500degs. Fahr. That is a temperature that can hardly be conceived; the melting point of iron is only about 1,200degs. Fahr., the melting point of platinum, which is one of the most refractory metals we have, is about 3,000 Fahr.; but here in the arc we have the intense temperature that nothing can withstand, equal to 8,500degs. Fahr. The colour is really due to the combustion that takes place between the materials forming the arc. I have just used two pieces of carbon, but I will now try other materials—copper, iron, and zinc. You will see a difference in the colour of the light, due to the fact that metal is burned in the arc instead of carbon. Every metal has its own distinct and particular colour, and the presence of the different metals can be detected by the character of the small arcs produced.

"I have shown you that we have two modes of producing intense heat, and therefore light, by electricity. I want now to show you how we produce electricity. The first essential for the production of electricity with a hand machine like this is a good dinner. The energy provided by beef or mutton enables the operator to turn the big wheel of the machine, whence motion is transmitted to the apparatus for producing the electricity. This machine when rotated causes a coil of copper wire to be whirled in a magnetic field, and that rotation of the coil in a magnetic field converts the energy derived from the grass and the mutton through the machine into electric currents; those electric currents flow through wires that are under the table, they will appear in the two wires I hold in my hand, and will, I hope, reappear in the little glow-lamps I have before me in the shape of heat and then of light when I attach the wires. The light of the glow-lamp is of just the same form of energy as that which passed from the sun to the earth, and, by beginning backwards from the lamps we have light, heat, electric currents, mechanical motion, food or fuel in the shape of mutton, grass on the South Downs, to the sun. Whichever way it is taken you will find there is direct action between the sun and the glow-lamp. The lamps are now burning, and you see that we are able to produce electricity to our hearts' content. Downstairs there is a gas-engine; the gas-engine is at work; the gas-engine works because the gas supplies energy which, stored up in the bowels of the earth in the form of coal for ages and ages, has been extracted; it has been converted into gas at the large gas works down the river Thames, it has been brought up here, it is burned in the gas-engine, and produces energy in the gas-engine exactly in the same way as the mutton or beef produced energy just now. There is a dynamo downstairs exactly like the dynamo that we have upon the platform, and the current that is produced is exactly as the current we just obtained, and is sending electricity through all the lamps in this room. The currents of electricity passing through the lamps are producing intense heat, the heat is producing the incandescence of a fine carbon filament, such as I will show you directly, and the consequence is that we are now being lighted in this room by the energy that unmistakably and undisputably arrived on this earth millions of years ago in the form of sunshine."

After describing the arc and incandescent or glow lamps, and with the assistance of Mr. Sellar, of the Brush Company, actually making one of the latter before the audience, the lecturer went on to say:—"The form of lamp that is being made before us is of the ordinary size that we see used generally, but there are a great many different sizes of glow-lamps. For instance, here is a very small lamp; above me you will see, if I may call the small one a dwarf, there is a giant glow-lamp. It is a lamp invented by the Honourable Charles Parsons; it is made by the Sunbeam Lamp Company, of Gateshead, and is called the Sunbeam Lamp; it has the same proportion to an ordinary lamp that an ostrich egg has to a hen's egg, and the light from it is of equally large proportion, as you see now the current has been turned on to it. It gives a light of 400, candles, but it is rather too brilliant I see by your faces, and we will go back to our old friends of the ordinary size. There are also above us lamps of various sizes; there is a 5 candle, 10 candle, 16 candle, 20 candle, and a 100 candle lamp. Here also are a 50 candle Swan lamp, a 16 candle Swan, and an 8 candle Swan lamp. There are the ordinary 16 candle lamp; these are being burned from the Grosvenor Gallery. Here is a miner's lamp, which is supplied with a current by the Schanschieff battery, the same as I showed you at first; the peculiarity of this arrangement is that when the battery is turned upside down the light goes off, the zincs and carbons occupy one half of the cell, and the solution the other half, the zincs and carbons being at the bottom, and the battery is not excited unless contact is made with the carbons and zinc. Such a battery as this will maintain its lamp for 12 or 13 hours. There are several forms of the Schanschieff battery. Here is a portable form, and lamp connected with it by a flexible wire, which can be used when travelling; or in the night, when you want to know the time, you can have a lamp and battery like this by your bedside, and you can turn it upside down, and produce a light, see the hour, and turn the battery back.

"These glow-lamps are used for different purposes and ways. They may be used with care, they may be used recklessly; their duration depends a great deal upon the care with which they are used. A practised eye, one who is accustomed to deal with electric lamps, can tell at a glance when the lamp is raised to a proper incandescence; but there is a point in all lamps that is a sign of danger, and indicates 'breakers (or breakage) ahead.' Whenever in an electric light installation a glow-lamp begins to show a blue effect, then breakers are ahead; the current must be reduced or other steps taken. I want to show you this blue effect, which is extremely pretty, and I want you to see the gradual stages through which a lamp passes, from long life to death, or rather to a very short and merry life. We can make the life of a lamp just exactly what we like; we can make a lamp last a minute, or we can make it last 100 years, and the number of years of its duration is simply dependent upon the current employed. I have here a glow-lamp, and I pass a current through it. There is no blue effect at present; the current is increased and the carbon filament is raised to a high state of incandescence. In such a state it would not last for a long time, not more than ten minutes or a quarter of an hour; but it does not show the blue effect yet. On further increasing the current the blue effect appears, though I doubt whether it is visible to many of the audience; a little more current is put on, and the blue effect is very marked, the globe itself looks very brilliant, and, there the current has been increased until the filament has parted.

"It is always better when making an observation or experiment to know what you are going to see, so that you can direct your attention to exactly what is being done or to what you want to know. If I put another lamp through the same experiment you will be better able to understand this blue effect, and see just that point where the lamp is about to give out. The current is now on, and is being gradually increased; the lamp is now intensely blue—there, it has gone in the same way exactly

as the other one did. The way in which lamps burst is sometimes very beautiful: they disintegrate, they seem to volatilise, and the substance of the lamp is projected with great force against the side of the globe. On the table there are several beautiful specimens showing this effect.

"The glow-lamp in process of manufacture before you is now being unsealed from the pump; it is now exhausted, and we will pass a current through it so as to raise it to incandescence. The current is now on, and you see the lamp burns with full brilliancy. The next experiment is rather a cruel one, because it is wilful destruction. I will not destroy the lamp that has just been made before us, for I will keep it as a memento of this evening. I want to show the safety of the electric lamp. Many people imagine that there is a great deal of danger about it. I will take a handkerchief, and in it place a lighted lamp, when, on the globe being broken the carbon filament instantly goes out, and there is no damage to the handkerchief, or the slightest appearance of scorching or heating upon it. On breaking that lamp you heard a report. That is due to the vacuum, which, on sudden rupture, the air rushes in to fill. These lamps will not only burn in air, but will actually burn in water. Here I have a lamp which on placing in a bowl of water continues alight in the water just as well as in the air. You can imagine what an immense boon that is to our divers and others who unfortunately have to work under water for our benefit.

"I will not attempt to occupy your time in speaking of the beauties of this wonderful light, how it removes really poison from our air, how it is very good for sore eyes, because it burns with such steadiness that those who work under it really never find, in any shape or form any inconvenience or discomfort to the eyes. It is extremely cleany; it does not fill the air we breathe with noxious fumes. People are little aware or it, but it is a very simple calculation to show that thirty gas-burners produce a gallon of water in an hour, so that if you have thirty burners in a shop, for instance, alight for six hours, six gallons of water are produced, and the water can very often be seen running down the cold windows of shops. That water absorbs sulphur and sulphuric acid, and when deposited on books and decorations destroys them. If we could only get the electric light cheap, delivered at our doors, then everybody who has an idea of luxury and comfort would at once take it."

CORRESPONDENCE.

DR. O. LODGE ON MODERN ELECTRICITY.

To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR: Whether static electricity is associated with imaginary kinetic vortices in magnetism; or whether "electricity in radiation has anything to do with wave-velocity, wave-lengths," &c., &c.; or whether heat cannot be conveyed by radiation; these and many other points in the extended treatment may well justify being questioned; but on this occasion I desire to confine myself to a few points briefly, which may be of interest to any ordinary student of electricity.

The section on "Conduction in Metals," is hypothetic when compared with my carefully reasoned exposition (*Electrician*, July 22, 1887), where the facts observed may be thus summarily condensed:—

1st. That an opposite binary motion subsists in the wire.

2nd. That under all circumstances, the metal loses an atom or ion for every atomic change or unit of current, while at the other end an atom or ion of E or something (whether it will be matter or force) is correspondingly lost or given up.

3rd. That as these ions cannot pass through each other, they must do so spirally, and so produce the known inductive effects at right angles to every current, whether it be metal or fluid.

4th. That this friction of the moving particles must produce heat, as all or any friction does.

Now let any independent thinker compare this brief statement with the lengthened reasoning and varied hypotheses of the text.

The section "Conduction in Liquids," comprising four columns, is tedious, complex, and very hypothetic, compared with the treatment referred to, viz., that the liquid circuit is simpler, and more easy to understand, inasmuch as we have nothing to do with the unknown E, whose only known elements or ions are observed, and using the terms +H and −O in a representative sense, it is plain that for every atomic action or unit of current that O is lost on one side, precisely as H is lost or given up at the opposite end, and as in the metal, so here the inductive effect is a spiral or circular one.

Having said this we have said all, but as the subject has been so inextricably mixed up with kinetic and electric hypotheses it may be well to moot a few comparisons.

1st. If the opposite progression of + and − ions took place side by side, *as represented*, then their inductive effects would be lateral in a flat sense, whereas we know it to be so different, and we also know that a + current going in one direction and a − current in the opposite direction are only different expressions for the same thing.

2nd. All the hypothetic propositions about the ions carrying different charges of electricity are utterly superfluous, a grandiloquent talking about things of which absolutely nothing is known; whereas the inductive properties of known elements, or ions, is something actually known and easily understood. Why, then, should our knowledge of these properties be obliterated or ignored in order to introduce occult or imaginary charges to accomplish that for which the ions are so manifestly fitted?

3rd. As to the different valency charges of electricity, it is a fashionable hypothesis that the ions travel at different rates; "for each of these atoms in the free state possesses a charge of electricity: the H atom a certain amount of +electricity; and the O twice as much −electricity; and hence they travel at different rates."

Of course all this confusion comes of our mistaken modern chemistry; but the great French chemists, and many others, have never bowed to this delusion. They know that O = 8 is electrically and chemically the true equivalent of H = 1, or Cl = 35·5, &c., and that this is patent in a thousand chemical ways.

In the section "Condition of the Medium" the following distinction does not indicate clear views:—"The induction of static electricity is an electro-static strain; that of current is an electro-kinetic strain."

But I think the doctor is too clear not to see otherwise than, as the former is a static strain, so current induction is no less essentially static, so long as equality of current subsists. Both equally vary under varying conditions, but in the section "Energy of Current," the whole secret of previous mystification comes out, and the seat of electric or propulsive energy is not where the chemical action takes origin, but somewhere mysteriously or kinetically all along the circuit, and not in the metal or conducting circuit, but in the surrounding medium.

May we be forgiven if we refuse to follow into such long and devious paths, ending in a vast wilderness of mathematical maze? Life is too short and time is too precious, while the simple truths of nature are so specially attractive and inviting.

But just one word on the section "A Voltaic Battery." We read between the lines most of the simple facts referred to, but the sins of omission and commission deserve a passing notice.

1st. That nothing is said as to how these opposite ions pass each other, and far more important still, nothing is said of the inductive functions of the transit or current, yet these are among the most ordinary or A B C facts of common observation.

2nd. The denuded facts are mixed up with interminable if not blinding considerations of extraneous hypothesis.

One is the fashionable idea that the ions are in a beautifully kinetic sense, "either actually dissociated, or so frequently changing (partners) at random, from molecule to molecule, that the direction of their motion may be guided by a feeble force." Prof. Poynting has shown, on the principles developed by Maxwell, "that the battery models should not have a source of power at one place; but that it should

T^1, passes thence to the top of the spring, then down the spring into the movable coils C C^1, from there to the steel cup E, through the contact point to the iridium-tipped steel pivot, from that through the fixed coils, and so back to the other terminal, T. The windings of the movable coil are so arranged that it is astatic, and not influenced by a vertical or horizontal uniform field. This is important in an instrument to be used in the neighbourhood of powerful magnets.

The movable coils carry a light aluminium needle, Q, which projects up through a slit in the dial plate, opposite to the zero of the scale.

The whole instrument is contained in a small wooden box, about 4½in. square by 3in. deep. On opening the box a dial plate is seen having a circular scale divided so that the volt readings are obtained without any calculations. The operation of taking a reading is as follows:—The box is first levelled on the table by means of a wooden wedge provided for the purpose.

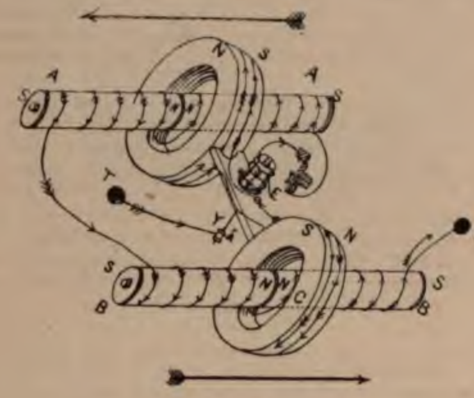


FIG. 4.

The central hollow boss is first turned until the mica index finger is at the zero of the scale. The aluminium index carried by the movable coils, which projects up through a slit in the dial, should also be opposite the zero. If this is not the case the mica index finger has to be shifted. This is accomplished by slacking up the milled head on the top of the central boss and re-adjusting the index until the mica index finger and the aluminium index of the movable coils both stand opposite to each other at the zero. The current is now passed, and the electro-magnetic action causes the movable annular coils to be shifted along the fixed coils, displacing the aluminium index. The central boss, carrying the upper end of the spring, is then turned until a torsional force is brought to bear on the movable coils, bringing them back against the electro-magnetic forces into the zero position. It will now be found that the upper end of the spring will have been twisted

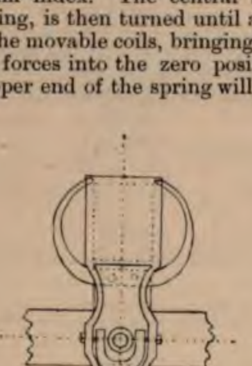


FIG. 5.

through a certain angle, as indicated by the position of the mica index finger. The value of the current passing through the instrument is proportional to the square root of this twist required to bring back the coils into their zero position, and, as the force brought to bear on the coils is proportional to the angular displacement of the upper end of the spring, it follows that the square root of the angular displacement of the mica index finger required to maintain the movable coils at their zero position is proportional to the strength of the current flowing through the instrument. To avoid any calculations or reference to square-root tables, the dial is graduated in the following manner:—If the instrument is intended to read, say, from 20 to 110 volts, then one complete turn, or 360deg. displacement of the index, is *required to balance* the electro-magnetic force due to 110 volts on the terminals of the instrument. The angular displacement for x volts is, then, $\frac{360\times x^2}{(110)^2}=\frac{18}{605}\times x^2$, measured in degrees, and accordingly the positions for all volt values from 20 to 110 can be set off directly on the dial. The index needle is then simply turned until the aluminium index is brought back to zero, and the dial reading gives at once the volts. This form of graduation has the advantage that the scale interval corresponding to one volt is greatest in that part of the scale which will be in each instrument presumably most used.

In order to render the instrument portable, means are provided to raise the movable coils off the point P by the action of closing the box. A clutch-bar, K, is so arranged and pivoted, that by means of a pin, R, sliding in a hole in the box a pressure on the upper end of this pin (H, Fig. 1) raises the coils, C C^1, and relieves the iridium point of the pressure of the movable coil-bar.

It is not desirable that the movable coils should be taken up and let down suddenly on the pivot, and to make this action deliberate the box lid is opened and closed by a screw. The user is thereby compelled to open the box slowly and let down the coils with a gentle motion on to the pivot P.

The voltmeters are constructed to work over various ranges. One type ranges from 20 to 110 volts. By associating a resistance coil with the voltmeter, the resistance of which is equal to that of the voltmeter, the volt values of all the readings become doubled and the instrument becomes available for use between 40 and 220 volts. In order to give a little margin over and above the 110 and 220 volts, the graduation is continued, according to the square-root law, along an outer circle. A little more than one complete twist of the spring enables a reading to be taken up to 115 or 120 volts on the 110-volt instrument, or to 230 or 240 on the 22-volt instrument. In the 110-volt instrument (construction A), the following are the electrical and mechanical data of the instrument:—The weight of the movable coils complete is in all 20·27 grammes. The number of turns of wire is 960, on both coils together, and the total resistance is 300 ohms. The four fixed coils have each 840 turns of wire, or 3,360 turns in all, and a resistance of 1,200 ohms. The total resistance of the voltmeter is therefore 1,500 ohms. The temperature-resistance variation coefficient has been carefully determined for a mean temperature between 15deg. and 30deg. C. for the particular kind of German silver wire used, and it is ·0273 per cent. per degree. Accordingly, as far as regards change of temperature as a whole, it requires an alteration of 30deg. C. to make a change of 1 per cent. in the value of the voltmeter readings. To prevent, as far as possible, heating of the coils, each voltmeter is provided with a key. In using the instrument the first operation after opening should be to level it carefully, by inserting, if necessary, the wooden wedge provided under the front or back side until the pointer on the movable coils swings freely from side to side.

(To be continued).

ELECTRICAL MEASUREMENTS, ESPECIALLY AS APPLIED TO COMMERCIAL WORK.*

BY PROF. WM. A. ANTHONY.

The lecturer was introduced by Prof. Edwin J. Houston, as follows: Ladies and Gentlemen,—We are fortunate this evening in having with us one well known in electrical circles in this country. Indeed, so well and favourably has he been known as a practical electrician, that he has been induced to leave a position which he has for so many years held with distinguished success. I take pleasure in introducing to you Prof. Wm. A. Anthony, formerly in charge of the Department of Electrical Engineering in Cornell University, and now consulting electrician of the Mather Electrical Company.

PROF. ANTHONY: Mr. President, Members of the Institute, and Ladies and Gentlemen,—The subject I have chosen for this evening's lecture is one of the driest that could well have been chosen, but I have believed it to be of sufficient importance to warrant its presentation to an audience such as I suppose would be attracted to the Franklin Institute meetings. Thousands of men and millions of capital are to-day interested in the applications of electrical science. We have come to a point where haphazard work is no longer admissible, where electrical currents must be gauged and measured, where the electrical properties of materials must be accurately determined; where, in short, machines and apparatus must be built to a gauge, and their products measured electrically as well as mechanically. As in mechanical construction we have gone beyond the use of the foot-rule and carpenter's square, and are fixing our dimensions by standard gauges to the ten-thousandth of an inch, so in the electrical construction we have gone beyond measurements by rude and imperfect instruments and have got to a point where, if our machines and apparatus are to find their place in the

* Abstract of a lecture delivered at the Franklin Institute.

markets of the world, we must gauge our work by accurate electrical standards.

What are the electrical quantities we have to measure? Before attempting to answer this question let us consider for a moment the origin of the terms we shall have to use. Our electrical nomenclature has been derived from the fluid theory of electricity. We talk about an electrical current as though something were flowing; we talk about quantity of electricity as though we considered it something to be weighed or measured; we talk about capacity for electricity as though a body could be filled with and hold a certain quantity of it, as a vessel may be filled with water. Whence comes the idea of an electric flow?

If we go back to the early electrical experiments where insulated bodies where "charged" and then discharged—the electricity drawn off, as it were—by a wire connecting the insulated body to the earth, we see that the idea of something accumulated in the body and then conveyed away by the wire was a very natural one, and when we found that the wire was heated, the passage of *something* through it seemed to be proved. Then came the voltaic battery and the evidence of greater and greater effects as the cells in series were increased, a close analogy to increasing pressure causing a more rapid flow of fluid. It was seen that many cells in series gave power of overcoming obstacles, that insulation had to be more perfect to prevent escape. Hence the terms high tension and low tension, as these were applied to gases.

There is some misapprehension among those who have had only a practical acquaintance with electrical phenomena, and do not know the fundamental principles. I hear a great deal of talk about high tension currents and low tension currents, as though the currents themselves were different. It should be understood that a current of one ampere is always a current of one ampere, always conveys one coulomb per second whether the tension be high or low, just as a stream that conveys one gallon of water per second, is the same stream whether under high or low pressure. The term tension is a misnomer as applied both to electricity and to gases. Pressure is the proper term for gases, and may be used by analogy for electricity. Potential is the scientific term for the electrical condition for which the word tension has been used. We can best understand it by drawing the analogy between it and fluid pressure. We find in the evening that the gas is burning dimly. We say at once, too little pressure in the mains. If more pressure is put on, more gas is forced through the burners and our lights burn more brightly. If our incandescent lights burn dimly, it is a lack of potential. Let the potential in the wires be increased, more electricity is forced through the carbon filament with an improvement in the light. It is not the greater pressure that gives you the brighter gas light, but the larger quantity of gas that the greater pressure supplies. So it is not the increased potential that causes the increased brightness of the carbon filament, but the greater flow resulting from the higher potential.

The electrical quantities we wish to measure are then *quantity*, which is measured in units called *coulombs*, and may be considered as analogous to pounds of a gas or liquid—*potential*, measured in *volts*, analogous to pounds per square inch of fluid pressure; *capacity*, measured in *farads*, analogous to cubic feet of a vessel for holding fluids; and *strength of current*, measured in *amperes*, for which there is no close analogue in fluid measurements.* Yet in electrical measurements, strength of current is, perhaps, most important of all, and furnishes the fundamental unit of the system. Another quantity of great importance in electrical measurements is the *resistance* of bodies to the flow of electricity. It is measured in *ohms*, and may be compared, qualitatively, to the frictional resistance which fluids experience in flowing through pipes.

Let us consider now these several quantities and their relations to each other, from the standpoint of the analogy of a flowing fluid. Here is a pipe carrying gas. We wish to know how much gas is flowing through it per hour or day or month. This the gas meter professes to tell us, but there is sometimes a question whether its statements are truthful. We could run the gas into a suitable vessel and measure it, but that would be inconvenient in the practical use of the gas because we consume it as it flows. But whatever method we use our object is to determine the total quantity of gas delivered in a given time, and not the rate of flow at any instant. By *rate of flow* I do not mean the velocity of the gas, but the rate as indicated by the quantity of gas flowing in unit time when the flow is uniform. In this sense, when the same quantity of gas per minute is flowing, the rate of flow is the same whatever the size of the pipe. But there is no important effect of the gas dependent upon the rate of flow; the pipe that conveys it acquires no new properties or powers. In fact, no effect is produced by it that would indicate to us whether the gas were flowing or not. To be sure, heat is generated by the friction of the gas, but in practice this is too small to be perceived and is of no consequence. Moreover, the heat generated is a function of the velocity of the gas, and not simply of the rate of flow as I have used that term. We have, therefore, no need to know the rate of flow of a gas, we make no attempt to measure it directly, we have no unit in which to express it, and no distinctive name for it as a quantity.

Now let us compare an electric flow. Here is a wire conveying an electric current. We know there is something going on in it because we see the effects on beyond, just as we know that gas is flowing in this pipe because we see it burning in yonder burner. As with the gas, we can determine the quantity of electricity flowing in a given time by measuring its effects. Electricity flowing through acidulated water generates hydrogen and oxygen gases. The quantity of these gases generated in a given time may be taken as a measure of the total amount of electricity flowing. Electricity flowing through a solution of a metallic salt, as copper sulphate or silver nitrate, deposits the metal. The weight of deposited metal will measure the total flow. But these methods, like the methods of measuring gas, tell us only the average rate of flow, and not the rate at any given time. But a conductor conveying electricity, unlike a conductor conveying fluid, exerts forces due to the current in it. This wire will deflect a magnetic needle, will attract iron filings. (Shown by experiment.) In short, it develops all around it a magnetic field.

This effect of an electric flow is of such great importance and finds such a multitude of applications, that the rate of flow upon which it depends is a more important element than the total quantity flowing, and the unit in which we measure it, the ampere, is based upon this magnetic effect. This unit has taken its place with our foot, and pound, and gallon, and is making its way very rapidly into the popular vocabulary. Notwithstanding the fact that it is coming into such general use, there seems to be a great deal of confusion as to what an ampere is. It seems to me important that the true definition of this unit current should not be lost sight of, and I wish to protest against the admission of the arbitrary definitions that are finding their way into electrical literature.

The true ampere is based upon the absolute unit current as defined by the British Association committee. The absolute unit current is that current, a centimeter length of which will produce a unit magnetic field at a centimeter distance, or it is that current which when flowing in a conductor bent into a circle of one centimeter radius, will develop at its centre a magnetic field of intensity 2π. This is the foundation of the electromagnetic system of electrical measurements. Upon this unit are based all the other units of the system. The *ampere is one-tenth of this unit.* This was the value of the weber, the former name of the unit of current, and the Paris congress, in changing the name to the ampere, did not change its value, but expressly voted that this should continue to be its signification.

Now to measure an electric flow in amperes. We may bend the conductor into a circle and compare the field produced at the centre of the circle with some known magnetic field, such as the magnetic field due to the earth. This is accomplished by means of the tangent galvanometer. The conductor, of one or many circular convolutions, is placed with its plane in the magnetic meridian; in this position the force it produces is at right angles to the earth's magnetic force and a little needle placed at the centre of the circle will take a position depending on the ratio of the two magnetic fields. If the needle stands at 45deg. with the magnetic meridian, the two fields are equal, and, in general, the ratio of the field produced by the current to that of the earth is the tangent of the angle that the little needle makes with the meridian.

In the great tangent galvanometer of the Cornell University, this method is employed to measure currents up to 300 amperes. The great difficulty in this method is that the earth's magnetic field is not constant, but varies from day to day and from hour to hour. In all work where accuracy is aimed at, the horizontal intensity of the earth's magnetic field must be determined at the time of making an observation for current. In the Cornell instrument a coil suspended by a wire serves to determine the horizontal intensity by balancing the force developed by a current in the coil in the earth's field against the force of torsion of the suspending wire. But another and more serious difficulty is met with when any attempt is made to use this method for ordinary practical work. The earth's magnetic field is greatly affected by the presence of magnetic substances. A small mass of iron is sufficient to change very greatly the value of the earth's field in its vicinity. A large magnet or a dynamo may at many feet distance change the earth's field by a hundred per cent. The tangent galvanometer can only be used therefore where there are no disturbing causes. It cannot be used in a dynamo station or in a workshop. But in a suitable place it is invaluable as a standard with which to compare other instruments. The Cornell tangent galvanometer is mounted in a special building, constructed entirely without iron, and placed at a distance from all other buildings. The earth's field there is subject only to such changes as are due to natural causes, and with the appliances for determining these changes the highest class of work can be done.

(To be continued.)

* [The rate of flow—say in gallons per minute—of a fluid in a channel or pipe, or quantity of fluid passing, divided by time, is a close analogue.—Ed. *E. E.*]

FORTHCOMING BRUSSELS EXHIBITION.

MEETING AT THE MANSION HOUSE.

A meeting of exhibitors in the British Empire Section of the International Exhibition of 1888 was held at the Mansion House on Tuesday.

The **Right Hon. Polydore de Keyser** took the chair at 3 p.m.

The **Chairman,** in opening the proceedings, said he had received a letter from the president of the exhibition asking him to support Mr. Bapty in forming a committee in London to promote the interests of this exhibition.

Mr. S. Lee Bapty, Commissioner General for the British Empire Section, said the scheme took root early last year, and a committee of Belgium manufacturers and merchants had been formed under the presidency of the Count of Flanders. The International Exhibition now proposed was the first that had ever been held in Brussels, and it had the heartiest support of the King and Government. The site selected covered over 100 acres, and was situated in the best part of the city. The grounds in connection were beautifully laid out. He had been to Brussels to consult the committee as to a British section, but found the prices for space were so high that after consideration it was decided to have a separate building, which is now being erected. When he told them this building formed part of the main structure at the Manchester Jubilee Exhibition he was sure they would agree with him that it was well suited for the purpose intended. In response to invitations he had issued, a number of noblemen and gentlemen had consented to be placed on the committee, including the Earls of Derby, Lathom, and Aberdeen; Lord Vivian, Lord Claud Hamilton, M.P.; Sir B. Samuelson, M.P.; Sir R. N. Fowler, M.P.; Captain Sir Douglas Galton, Sir Frederick Abel, Sir J. C. Lee, Sir G. H. Chubb, Sir H. Grubb, Sir James King, Colonel E. S. Hill, C.B., M.P.; Lord Provost of Glasgow, Mr. J. Corbett, M.P.; and the Mayors of Birmingham, Leeds, Liverpool, Manchester, Newcastle, and Sheffield.

A resolution was passed thanking the Lord Mayor for consenting to become President of the Section.

In response to the vote of thanks, the **Lord Mayor** said he thought that the movement would do good to the commerce of this country, and also benefit Brussels, in which city he took a warm interest.

Mr. Bapty said the time for receiving applications for space had been extended to the 15th of February.

LEGAL INTELLIGENCE.

TELEPHONE WIRES IN THE CITY.

In Queen's Bench Court I. there was heard on Wednesday the case of Smart, Black and Company *v.* United Telephone Company. This was a motion for a new trial on behalf of the defendants, the jury at the trial before Mr. Justice Mathew having given a verdict for the plaintiffs, with damages. The action was brought by a firm of importers of Swiss embroidery and haberdashery, carrying on business in the City, to recover compensation for injury to their stock, caused, as they alleged, through the fall of a telephone wire belonging to the defendants, which was stretched across the roof of their warehouse, and which fell during the great snowstorm of Christmas, 1886. It was alleged that the wire in falling swept the snow off a portion of the roof, and caused a gutter to give way, in consequence of which, when the thaw came during the Christmas holidays, snow-water entered the plaintiff's premises and damaged their stock. On the other hand, defendants contended that the falling of the wire had nothing to do with the breaking of the gutter, which was due to the weight of the snow. Their Lordships refused a new trial.

COMPANIES' MEETINGS.

EASTERN TELEGRAPH COMPANY (LIMITED).

The 31st half-yearly general meeting of the Eastern Telegraph Company (Limited) was held on the 19th inst. at Winchester House, Old Broad-street, E.C.

Sir John Pender, K.C.M.G., presided, and, in moving the adoption of the report, observed that the revenue for the half-year ended September 30 last had been £291,265, being a decrease of £964 as compared with the revenue for the corresponding period of 1886. The directors considered that satisfactory, because the large decrease of revenue caused by the reduction of the tariff to India was sensibly diminished, and, indeed, the improvement in traffic with Australia, China, and other countries in the Far East had more than recouped the loss on Indian messages. Their traffic with Egypt, on the other hand, showed a further falling off, but that had been made good by an increase of messages exchanged with Portugal and South America. For the current half-year their prospects were most favourable, and it was hoped that next July, when they presented the accounts for the financial year to March 31, they would be able to give the shareholders a small bonus in addition to the 5 per cent. dividend. The total working expenses of the half-year had been £79,936, being a reduction of £1,085. The general expenses in London had been £8,012, or £48 more; and at the stations the expenses had been £56,386, or a decrease of £1,743. The principal reduction, however, had been in repairs and renewals of cables, which had cost £34,102, or £19,863 less than in the corresponding period of 1886. After paying all expenses and providing for debenture and preference interest, they were able to pay an interim dividend on the ordinary shares at the rate of 5 per cent. per annum, and to carry forward £29,397, or £16,306 more than at the same date in 1886. That was a considerable sum, but until they closed the year there was always an amount of uncertainty as to whether the sum carried forward would be materially reduced by interruptions to the cables. At the last meeting he referred to the difficulties they had had with the French Government in connection with the renewal of the Company's wire through France. That privilege would expire next year, and though they paid a good deal of money to the French Government for it they had not yet been able to get a renewal. They had, however, laid a fresh cable from Porthcurnow to Lisbon, Gibraltar, Malta, and Zante. It was working in the most satisfactory way, aiding them in carrying their traffic, and it had placed them in a perfectly independent position if war broke out on the Continent at once. He referred at the last meeting to the improvement in trade, and he was glad to say that the improvement was still continuing. They had now all but recouped the amount of money which they had been compelled to give up at the Telegraph Conference at Berlin, and he hoped they would now be enabled to resume paying their old bonus of 1 per cent. If they had kept their reserve fund intact and laid their new cables out of capital their reserve fund would now stand at over £1,000,000, instead of at £576,000. They had, however, instead of burdening capital for the purpose, preferred to draw on the reserve fund and on current income. He congratulated them on the prosperous condition of the Company.

The **Marquis of Tweeddale** seconded the motion.

Mr. L. Nicholson inquired whether there was a prospect of the cable being duplicated to the Philippines, a very important Spanish possession. He afterwards moved a rider to the resolution cordially congratulating the chairman on the recent honours which had been conferred on him by the Queen.

Dr. Waller seconded the proposal.

The motion, with the addition of the rider, was unanimously adopted.

The **Chairman** warmly thanked the shareholders for the kindness which they had invariably shown him. If he were to relate the history of submarine telegraphy he would have to mention the names of a great many who had been associated with him; but he could not refrain from alluding to the eminent services of his colleague, Sir James Anderson. With regard to the question asked by Mr. Nicholson, the Eastern Extension Company were now in negotiation with the Spanish Government on the subject.

The retiring directors and auditors were then re-elected, and the meeting terminated.

DIRECT UNITED STATES CABLE COMPANY.

The 21st ordinary general meeting of the Direct United States Cable Company was held on Friday, the 20th inst., at Winchester House, Old Broad-street, E.C.

Sir John Pender, K.C.M.G., presided, and in moving the adoption of the report observed that the revenue for the half-year, after deducting out-payments, had been £23,003, and after paying working and other expenses a balance of £7,138 remained as the net profit of the half-year. That was at the sixpenny tariff. The balance of £7,138, with the addition of £5,004 transferred from the reserve fund account —out of interest received on the investments—made a total of £12,142, which had been appropriated in paying two dividends of 2s. each for the quarters ended June 30 and September 30 last. A dividend of 2s. a share for the quarter ended the 31st ult. had been declared, and would be payable on the 24th inst. The revenue at the sixpenny rate showed an increase of £3,399 as compared with the corresponding period of 1886, when the tariff was the same, but the progressive development in the traffic carried during the first half of 1887 had not been maintained. The expenses in London had been £458 less, but at the stations the amount had been £130 more. It was satisfactory to note that, notwithstanding the large traffic carried, and some additional outlay incurred through the action of the French Company, their total working and other expenses during the half-year had been less than in any previous half-year of the company's existence. The item of cost of removing their cables and station to Halifax remained for the present in the balance-sheet. Their investments continued to be worth much more than the company had paid for them. At their last meeting he expressed his belief that the sixpenny tariff would not be a permanent rate, but he stated at the same time that while the development of the traffic was going on, it would be a misfortune to make any change. They had, however, now arrived at a point when the sixpenny rate seemed to have ceased to bring an increase in the returns, and, therefore, the opinion he expressed at the last meeting as to the mode of dealing with the question he now entirely endorsed. The Western Union Company had taken an active part in the effort to settle the war of rates, and they had adjusted the land charges in a way which, he believed, was now working satisfactorily. That company had also acquired the control of the Baltimore and Ohio telegraph system. There had been some negotiations in America between Mr. Gould and Mr. Mackay, and they had been referred to this country, but the proposals were of such a nature that they could not be entertained. Had they accepted the proposals they would have been positively guaranteeing a very high rate of interest to a company which had laid cables that were not wanted, and, in short, it would have been giving a very high premium to that company. Speaking, he believed, with the full concurrence of his Board, he would be very pleased to see a conference of the different companies held to consider the question of what would be a fair rate both for the shareholders and the telegraphing public. The suit which the Anglo-American Company had brought against the French Company for seceding from the pool had ended—at least, the decision for the time being was in favour of the Anglo-American Company, who had been awarded damages to a considerable amount. He could not say whether the deci-

sion would be sustained on appeal, but he believed if the directors of the French Company, instead of appealing to the courts of law, appealed to the English directors as to meeting together and trying to bring about a more satisfactory tariff, it would be much better for telegraphy generally, and for the interests of all the shareholders. He made that remark with all courtesy and respect for the directors of the French company, from whom he would be glad to receive a communication on the matter. He was not prepared at that meeting to say definitely what the rate should be, but if they could maintain the present traffic at a shilling rate, it would not be a burden to the telegraphing public, and the result would be much more satisfactory to the shareholders. Referring to the transfer of the cables and station from Torbay to Halifax, and to the removal to the southward of Brown's Bank of the short cable which had previously lain across the bank, he expressed a hope that by the latter operation they would in future be saved considerable expense. They were also prepared, being at Halifax, to carry their cable on to Bermuda, should the Government desire them to do so.

Mr. William Ford seconded the motion.

In the discussion which followed, **Mr. Griffith** and **Mr. John Newton** congratulated the chairman on the honours which had recently been conferred upon him by the Queen. A hope was expressed that the vacancy at the Board would not be filled up; and **Mr. Guesdon** and **Mr. Witherby** thought that the directors might, in existing circumstances, give up a part of their fees.

The **Chairman**, in reply, stated that for the present the directors did not intend to fill up the vacancy at the Board which had been caused by the death of Lord Hawke. The agreement between the Company and the Anglo-American Company was very beneficial, and would last for many years. The directors, under the articles of association, were entitled to 25 per cent. more for fees than they had taken. They had to work at the present time very hard. It would be most imprudent of them to trench on the reserve fund proper, in order to increase the dividend.

The motion was then agreed to.

PROVISIONAL PATENTS, 1888.

JANUARY 13.

540. **Improved electric balloon pleasure carriages.** Thomas Needham, Park House, Fitzwilliam-street West, Huddersfield.

549. **Improvements in dynamo-electric generators and motors.** James Blackburn, 33, Chancery-lane, London, W.C.

584. **Improvements in the method of and apparatus for supplying electric railways or tramways with electricity.** William Leonard Madgen, 28, Southampton-buildings, London, W.C.

JANUARY 14.

609. **Improvements in apparatus for determining the poles of electrical circuits and generators of electricity.** August Berghausen, 38, Alexander Str., Berlin, Germany.

623. **Improvements in thermo-electric elements and piles.** Robert Jacob Gülcher and the Firm of Julius Pintsch, 28, Southampton-buildings, London.—(Complete specification.)

633. **Improvements in dynamo-electric machines.** Carl Coerper, 45, Southampton-buildings, London.—(Complete specification.)

JANUARY 16.

656. **Improvements in internal combustion thermo-dynamic engines.** James Hargreaves, 4, Clayton-square, Liverpool.

JANUARY 17.

698. **An improved holder and switch for electric lamps.** Robert Cornthwaite, Sunbridge-chambers, Bradford, Yorkshire.

705. **The telephone, consisting of a mouthpiece to be attached to the transmitter.** Leo Eugène Percy, 9, London-street, Southwark, London, S.E.

715. **Improvements in voltaic or galvanic batteries.** Theophilus Coad, 10, Thorpe-terrace, Thorpe-road, Forest Gate.

718. **Improvements in self-acting electric batteries or generators in which the liquids are automatically renewed.** Emil Guitton, 47, Lincoln's Inn-fields, London. (Marcel Sappey, France.)

727. **Improvements in thermo-dynamic electric machines.** Rankin Kennedy, 96, Buchanan-street, Glasgow.

729. **Improvements in electric batteries and elements therefor.** David Urquhart, 47, Lincoln's Inn-fields, London.

734. **Improvements in galvanic batteries.** James Noad, 321, High Holborn, W.C.—(Complete specification.)

742. **Improved apparatus for tanning hides and skins by the aid of electricity.** Lorentz Albert Groth, 3, Tokenhouse-buildings, London.

750. **Improvements in and relating to electric railways and to vehicles for use thereon.** Henry Harris Lake, 45, Southampton-buildings, London. (David Gustavus Weems, United States.)—(Complete specification.)

JANUARY 18.

789. **Improvements in the construction and application of transformers for the distribution of electricity for lighting and other purposes.** John Augustine Kingdon, 29, Marlborough-hill, London, N.W.

791. **Improvements in junction boxes for electric conductors.** Ronald Augustus Scott, 331, King-street, Hammersmith, London, W.

804. **Improvements in electric clocks.** Martin Pulvermann, 4, South-street, Finsbury, London. (Carl Bohmeyer, Germany.)

JANUARY 19.

873. **Electric igniting apparatus.** Léon Hen and Rudolphe Weinmann, 28, Southampton-buildings, London, W.C.

874. **Improvements relating to the repair of electric incandescent lamps.** Frederick Henry Judson, 77, Southwark-street, and William John Woodward, Judson's Electrical Works, Ewer-street, Southwark, Surrey.

COMPLETE SPECIFICATIONS ACCEPTED.

JANUARY 13, 1887.

563. **An improved dynamo-electric machine.** Henry Harington Leigh, 22, Southampton-buildings, Chancery-lane, Middlesex. (Jean Louis Clerc, France.)

JANUARY 15, 1887.

701. **Improvements in electrical meters.** Sebastian Ziani de Ferranti, 5, Stanwick-road, West Kensington, Middlesex.

702. **Improvements in dynamo-electrical machines.** Sebastian Ziana de Ferranti, 5, Stanwick-road, West Kensington, Middlesex.

JANUARY 17, 1887.

717. **Disc dynamo-electric machines and motors.** William Brooks Sayers, 24, Glycena-road, Lavender Hill, London, S.W.

FEBRUARY 25, 1887.

2959. **A new or improved combined bell-push and automatic switch for electric alarms.** Hippolyte Charles Chocqueel, 18, Buckingham-street, Strand, London, W.C.

MARCH 9, 1887.

3605. **Improvements in simultaneous telegraphy and telephony.** Charles Selden, 55 and 56, Chancery-lane, Middlesex.

MARCH 15, 1887.

3878. **Improvements in or connected with electric alarm clocks.** Henry Boardman, 20, Charles-street, Bradford, Yorkshire.

MARCH 16, 1887.

3943. **Improved instruments for measuring electric currents.** William Henry Douglas, 7, Cherry-street, Birmingham.

MARCH 19, 1887.

4138. **Improvements in safety devices in electric circuits.** Arthur Cecil Cockburn, 26, Petherton-road, Canonbury, N.

4153. **An improved mechanical telephone.** Thomas Harding Churton, Park-chambers, 35, Park-square, Leeds.

JUNE 10, 1887.

8329. **Improvements in electrical signalling apparatus for railways.** William Edward Langdon, Midland Railway, Derby.

SEPTEMBER 2, 1887.

11,923. **Improvements relating to the manufacture of plates or electrodes for primary or secondary electric batteries and to apparatus therefor.** Carl Ludwig Rudolph Ernest Menges, 45, Southampton-buildings, London.—Antedated 19th February, 1887, under International Convention.

OCTOBER 31, 1887.

14,768. **Improvements in the construction of switches for the making and breaking of circuits conveying electric currents.** Charles Mark Dorman and Reginald Arthur Smith, 24 Brazenose-street, Manchester.

NOVEMBER 28, 1887.

16,351. **Improvements in electric belts.** Alva Owen, 18, Buckingham-street, Strand, London.

NOVEMBER 29, 1887.

16,376. **Improvements in electric arc lamps.** Clarence Bingham Noble and Roland Darius Noble, 36, Southampton-buildings London.

DECEMBER 13, 1887.

17,157. **Improvements in galvanic batteries.** Henry Harris Lake, 45, Southampton-buildings, London. (James Orville Whitten, United States.)

SPECIFICATIONS PUBLISHED.

1886.

12,032. **Electric incandescent lamps.** A. Featherstonhaugh. 8d.

16,650. **Electric apparatus for the control of watchmen.** O. Skriven and F. Dvorak. 8d.

16,661. **Self-regulating dynamo-electric generators.** R. P. Sellon and others. 8d.

16,879. **Printing telegraphs.** W. S. Steljes. 8d.

1887.

266. **Electric telegraphs.** E. Edwards (Kunhardt). 1s. 8d.

3360. **Train signalling on railways.** S. T. Dutton. 8d.

16,120. **Voltaic batteries.** E. Tyer. 6d.

1852.

14,198. **Obtaining light, motion, &c., by electricity.** M. J. Roberts. 1s. 3d.

1878.

4847. **Electric lamps.** F. J. Cheesbrough. (Sawyer.) 11d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.	Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	98 to 100	1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼	25 July	10/0	India Rubber, G. P. & Tel.	10	22¼
12 Feb.	2/0	— fully paid	5	4¼	28 Oct.	12/6	Indo-European	25	39
28 Oct.	7/6	Anglo-American	100	40	16 Nov.	2/6	London Platino-Brazilian...	10	5
28 Oct.	15/0	— Pref.	100	66	16 March ...	5%	Maxim West rn...............	1	¼
12 Feb., 85...	5/0	— Def........................	100	14¾	15 May	5%	Oriental Telephone	11	⅝
29 Dec.........	3/0	Brazilian Submarine.........	10	12⅛	14 Oct.	4/0	Reuter's	8	8½
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	3½	1⅜
28 July	8/0	Cuba	10	12¾	28 July	12%	Submarine	100	135
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	96
14 Oct.	1/0	Direct Spanish	9	4¼	14 July	12/0	Telegraph Construction ...	12	38⅝
18 Oct.	5/0	— 10% Pref.	10	9½	1 July	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	9	30 Nov.	5/0	United Telephone	5	11⅞
12 Jan.	2/6	Eastern	10	11⅛	......	...	West African..................	10	5
12 Jan.	3/0	— 6% Pref.	10	14¾	1 Sept.	5%	— 5% Debs.	100	93
2 Aug.	5%	— 5%, 1899	100	109	29 Dec........	6/0	West Coast of America ...	10	5x
28 Oct.	4%	— 4% Deb. Stock	100	102½	31 Dec.	8%	— 8% Debs.	100	115
12 Jan.	2/6	Eastern Extension, Aus-			14 Oct.	3/9	Western and Brazilian......	15	9
		tralasia & China............	10	12⅛	14 Oct.	3/9	— Preferred	5½	6⅛
2 Aug.	6%	— 6% Deb., 1891	100	109	......	...	— Deferred..................	2½	3 3-16
3 Jan.	5%	— 5% Deb., 1900	100	105x	2 Aug.	6%	— 6% A	100	110
2 Nov.	5%	— — 1890	100	102	2 Aug.	6%	— 6% B	100	107
3 Jan.	5%	Eastern & S. African, 1900	100	103x	......	...	West India and Panama ...	10	1
12 Jan.	5/9	German Union	10	9¾	30 Nov.	...	— 6% 1st Pref.	10	10
14 Oct.	0/6	Globe Telegraph Trust......	10	5⅝	13 May, '80..	...	— 6% 2nd Pref.	10	6½
14 Oct.	3/0	— 6% Pref.	10	13½	2 Nov.	7%	West Union of U.S..........	$1,000	125
3 Jan.	5/0	Great Northern...............	10	14x	1 Sept.	6%	— 6% Sterling	100	104

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Dec. ...	£38,908	- £1,631
Brazilian Submarine	W. Jan. 11 ...	£4,491	...	Great Northern	M. of Dec. ...	21,600	...
Cuba Submarine	M. of Dec. ...	3,300	+ £175	Submarine	None	Published.	
Direct Spanish.....................	M. of Dec. ...	2,004	+ 222	West Coast of America	M. of Dec. ...	4,300	...
— United States	None	Published.	...	Western and Brazilian	W. Jan. 11 ...	3,613	...
Eastern.............................	M. of Dec. ...	57,703	+ 4,880	West India and Panama	F. Jan. 15......	2,509	- 467

Abbreviations: W., week; F., fortnight; M, month.

NEW ELECTRICAL COMPANIES, 1887.

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Shares.	Deposit.	Total Deposit.
Blockley Electric Lighting and Manufacturing....................................	£20,000	...	£5 0 0	...	...
Eclipse Electric Battery, Limited	100,000	£100,000	1 0 0	£0 10 0	£50,000
Electric Battery Brush, Limited	50,000	50,000	5 0 0	1 0 0	10,000
Extended Electro-Metal Extracting, Refining, and Plating, Limited	150,000	150,000	1 0 0	0 5 0	37,500
Jensen Electric Bell and Signal, Limited	100,000	100,000	1 0 0	0 6 0	37,500
Orient Electric Light..	5,000	...	250 0 0	...	...
Platinum Plating, Limited	60,000	59,100	1 0 0	0 5 0	14,775
Portland Electric Light..	45,000	...	5 0 0	...	...
Singapore, Straits Settlements, and Siam Electrial, Limited..................	60,000	39,000	5 0 0	2 0 0	15,600
South Metropolitan Electric Supply	250,000	...	10 0 0	...	...
St. James's Electric Light, Limited	50,000	50,000	5 0 0	2 0 0	20,000
Union Electrical Power and Light, Limited	500,000	125,000	5 0 0	2 0 0	50,000
Winfields, Limited..	160,000	120,000	5 0 0	3 0 0	72,000
Woodhouse and Rawson, Limited	200,000	105,000	5 0 0	1 0 0	21,000

CITY NOTES.

Western and Brazilian Company.—Mr. W. J. Andrews has been elected chairman of this Company in place of Sir Henry Drummond Wolff, who has resigned his seat at the board, and Lord Richard Howe Browne to a seat on the board to fill the vacancy.

Cuba Submarine Company.—The direc ors of the Cuba Submarine Telegraph Company (Limited), after providing for the dividend on the Preference Shares and placing £3,000 to the reserve fund, recommend a dividend on the Ordinary Shares at the rate of 8 per cent. per annum, tax free, leaving £972 to be carried forward.

United Telephone Company (Limited).—The directors have decided to call up the remaining amount payable in respect of their 20,000 new shares of £5 each (numbered 80,001 to 100,000), issued at £2 per share premium, viz., £2. 10s. on account of capital, and £1 on account of premium. The call will be payable on the 1st of *May next.*

National Telephone Company.—At the meeting of the directors of the National Telephone Company (Limited), held on Wednesday, it was resolved to declare a dividend for the six months ending December 31st last at the rate of 6 per cent. per annum on the first and second preference shares, and an interim dividend at the rate of 4 per cent. per annum (as against 3½ per cent. for the corresponding period last year) on the ordinary shares, and that the balance of £3,570 should be carried forward. The unaccrued revenue carried forward to the credit of next account amounts to £45,826, as against £38,722 last year.

Anglo-American Telegraph Company.—The directors of the Anglo-American Telegraph Company (Limited) recommend a balance dividend of 10s. per cent. upon the ordinary consolidated, and a balance dividend of 20s. per cent. upon the preferred stock for the year ending December 31, both payable on the 4th of February, less income-tax, to the stockholders registered on the 16th inst. After paying the foregoing dividends there will be an estimated balance of £2,300 to be carried forward. The above dividends, together with those already paid, will amount to £1 7s. 6d. per cent. on the ordinary consolidated stock, and £2 15s. per cent. on the preferred stock for the year.

NOTES.

Juvenile Lectures.—The abstract of the second lecture has unavoidably to be held over to our next number.

Old, but very good.—"Tommy, my son, what is longitude?" "A telegraph wire, papa." "Prove it, my son." "Because it stretches from pole to pole."

New Firm.—We understand that Messrs. Appleton, Burbey and Williamson have entered into partnership, and will immediately commence business as electrical engineers and contractors, at Balmoral Buildings, Queen Victoria-street, E.C.

Telegraphy in America.—It is reported that the petitions for government telegraphs, circulated by the Knights of Labour, are being returned to headquarters in Philadelphia with great numbers of signatures. A million names are expected.

Electric Traction.—At the meeting of the Northampton Tramways Company mention was made of the experiments being carried out on the West Metropolitan line, and a suggestion made that if these experiments proved successful electric traction should be adopted at Northampton.

The Telephone from Paris to Brussels and Amsterdam.—A third telephone line from Paris to Brussels is projected, and also, in connection with it, a line from Brussels to Amsterdam. Telephonic communication between Paris and Amsterdam would thus become possible.

Society of Telegraph Engineers.—The paper to be read at the ordinary meeting to be held at the Institution of Civil Engineers on February 9 is one by Mr. Gisbert Kapp, A.M.I.C.E., "On alternate current transformers, with special reference to the best proportion between iron and copper."

The Electric Light in Vienna.—According to the Electrotechnical Society of Vienna there are in this city and its suburbs 338 arc and 12,600 incandescence lamps in operation. This appears no inconsiderable figure when it is borne in mind that the commune of Vienna comprises but little over 10,000 gas burners.

Rather Abstruse.—According to *l'Electricien*, M. Felix Lucas has succeeded in the *electrical determination* (sic) of the real and imaginary roots of the derivative of any polynomial, by assimilating the curves of level or *cassinoides* to the equipotential curves produced by the points of electrodes in the experiments of Dr. A. Guébhard.

Electric Lighting in Leeds.—It has been decided by the Electric Lighting Committee to place 100 incandescent electric lamps in the mayor's rooms at the Town Hall. The arrangements for an installation to light the Fine Art Gallery, the Victoria Hall, and all other parts of the Town Hall and Municipal Buildings are to be considered by the committee in a short time.

Station Lighting.—Although the rumour current last week that the Citadel Station, Carlisle, was to be lighted by electricity was premature, we may gather from the crticisms that such a course would be welcomed by those who have to use the station. The rumour arose from the secretary having made, unofficially, some inquiries as to the possibilities and cost of such lighting. We have no hesitation in saying that every large railway station in the kingdom should adopt the electric light.

Communication with Lightships.—Replying to representations from the Dover Town Council with reference to communication with lightships, the Board of Trade state that experiments are to be made, over a period of eighteen months, with an electric cable between one of the Goodwin Sands lightships and the shore. If the experi ments are found to be successful, cables will be laid between the shore and lightships in dangerous positions.

Cost of Electric Lighting.—M. A. Bayou, former pupil at the Ecole Centrale has recently addressed to the Société Industrielle de l'Est an interesting communication in which he investigates the economical question in twenty-one cases where electric lighting has been substituted for gas in industrial establishments—amongst others the cotton-spinning factory at Blaniville-sur-l'Eau. His conclusions are favourable to the establishment of the electric light.

Magnetic Elements.—The following are the absolute values of the magnetic elements, as determined, on the first day of the current year, at the observatory of the park of Saint Maur (0° 9′ 23″ east long.; 480° 48′ 34″ north lat.):—

Declaration	15° 52·1′
Inclination	65° 14·7′
Horizontal component	0·19480
Vertical ditto	0·42215
Total intensity	0·46520

Metal-faced Wooden Type.—For posters, headings, &c., wooden type is in great favour, by reason mainly of its lightness; but the rapidity with which it becomes affected by wear and tear has hitherto been a great disadvantage. M. L. Duval has recently applied electro-metallurgy to metallising the face of the type, and, according to the *Moniteur Industriel*, has already obtained very favourable results in practice. The *galvanised type* is not only lighter, but is cheaper than metal type, and it is said to be equally durable in certain applications.

Catalogue.—We have received the catalogue of the United Electrical Engineering Company, which contains illustrated descriptions of the apparatus, as well as the prices at which the appartus can be supplied. We notice one or two new things in this list, such as the steelyard ammeters and voltmeters of Messrs. Drake and Gorham, p. 40; arc-ettes, or small arc lamps, designed for running in parallel circuit with incandescent lamps, p. 36; various designs of pulls and pushes, pp. 76-78. &c. The catalogue extends to nearly one hundred pages.

Reading.—An interesting and able lecture on "Electric Lighting" was delivered last week before the Literary and Scientific Society by Mr. Walter Palmer, B.Sc., F.C.S. The chair was filled by the President, Dr. Hurry, who, in his opening remarks, expressed the pleasure with which the society welcomed lectures on such modern and important discoveries as the applicability of electricity as an illuminating agent. We believe that Mr. Palmer, like Sir D. Salomons, has carefully investigated most of the apparatus employed in electric lighting at his own house.

Bradley's Cell.—This theoretically interesting couple was described by the inventor during the discussion on Mr. Willard E. Case's paper on "Electric Energy from Carbon without Heat." Both the elements are zinc; the negative being in contact with a hot concentrated solution of zinc chloride, and the positive in a cold dilute solution of the same salt. The latter solution is contained in a porous vessel standing in the hot solution, but kept cool and dilute by means of a constant stream of water passing through it.

The positive element, after the couple had been in action, was found to have lost weight, whilst the negative had gained little or nothing in weight The E.M.F. is 0.3 volt.

The Meriten's Process for Rendering Iron and Steel Inoxidisable.—In this process the articles to be protected from the effects of rust are made the anodes in an electrolytic bath of distilled water at 160deg. or 170deg. Fah.; a plate of copper, iron, or carbon serving as cathode. The surface becomes converted into *magnetite* (Fe_3O_4) by the action of the current; the operation being completed in from one to two hours. If too strong a current be employed, the oxide formed is pulverulent and without adherence. In the case of soft iron, the article, after a first oxidation, must be transferred to the cathode to reduce the oxide formed. After this treatment a very adherent deposit is obtained by a second oxidation.

Physological.—According to M. Poey, the learned Director of the Havana Meteorological Observatory, there is a very simple means of restoring to life those who have been struck by lightning, or who have accidentally completed the circuit of a high-potential dynamo machine. The means in question is to dash cold water over the whole of the patient's body—for an hour, if necessary—until some signs of life are exhibited. M. Poey cites a large number of cases in which people in a condition of asphyxia or "apparent death," consequent upon a discharge of lightning, have thus been recovered. This method of cure —the mention of which is unpleasant in the present weather—is said to have been largely and successfully adopted in the United States.

More Atlantic Cables.—The negotiations of the Dutch Government, says *Industries*, with the Pedro Seduengo-American Telegraph and Cable Company of New York are now so far advanced that it is almost certain that both Dutch Guiana and Curaçao will be in possession of double telegraphic communication with Europe and Holland before the year is out. The above company has an exclusive Brazilian concession for land cables on the coasts of the empire from America. The company proposes to lay cables from Visca, in Brazil, to Paramaribo, the capital of Dutch Guiana, or Surinam, and thence to Willemstad, Curaçao; provided Holland gives an annual subsidy for twenty years. The Dutch Government has agreed to do this. At Curaçao the above cables will connect with others, which the French Compagnie Télégraphique des Antilles is now laying to Hayti and Cuba.

The Electric Light in Italy.—At the great foundry at Terni the electric light has been in operation for about a year. At starting some difficulties were encountered, particularly on account of the vibrations occasioned by the steam hammers. These difficulties were soon overcome, and the lighting is now carried out without interruption. The installation comprises 100 Schwerd arc lamps, each of 2,000 candles, and over 300 Bernstein incandescence lamps of from 25 to 50 candles, distributed in 12 distinct circuits, which together comprise 10 kilometres of copper overhead wire. Of the above number of arc lamps 43 are employed in the lighting of the workshops, which cover a surface of 26,000 square metres, giving 610 square metres per lamp. The remaining arc lamps are devoted to out-door illuminations over a space of 134,000 square metres, giving 2,400 square metres per lamp. The incandescence lamps are distributed over about 3,350 square metres.

Brussels.—An important change has been made in the organisation of the management of the lighting of the town, M. Aerts, manager of the gas works, having been appointed surveyor of public lighting and gas mains in place of M. Wybauw, who takes charge of the electric lighting, clocks, and telephones. At present the electric light installation of the town only comprises the generating station at the gas works, from which the Theatre de la Monnaie, the Grand Place, and the Theatre du Parc are supplied. It is, however, probable that the municipality will favour a project of erecting an electric light station in the centre of the town, which would serve the principal restaurants, cafés, and some public buildings. Negotiations to this effect have been commenced with the Société Industrielle of Brussels. The Grand Hotel has already an installation of its own, but there are a number of first-class restaurants in the district around the Grand Place and the Bourse that would undoubtedly be glad of an opportunity to obtain the electric light from such a central station.

New Voltmeter.—Messrs. Siemens and Halske have introduced in their more recent installations of the electric light a new voltmeter, which contains neither springs nor permanent magnets, and is not liable, therefore, to require readjusting when once calibrated. The instrument consists mainly of a large circular coil fixed horizontally, and of a smaller concentric coil, mounted on knife-edges, which, in its normal position, is inclined to the former at an angle of about 60deg. These coils are so connected that a current traversing both tends to move the smaller one through the vertical position into the plane of the larger coil; this tendency being counteracted by a small weight. The movable coil carries a light index, which indicates the potential upon a scale on ground glass. The scale being transparent, readings can be taken on either side of the instrument, which is very sensitive. The size is, roughly, 6in. broad by nearly 10in. high. The movable coil is of 800 turns, and has a resistance of 34 ohms. The fixed coil has 1,150 turns and a resistance of 664 ohms. The instrument gives very correct readings from 60 to 110 volts.

Theory of the Telephone.—According to Dr. Rothen, the experiments of Messrs. Shelford Bidwell and Boekmann on the resistance of michrophonic contacts lead to the following rules:—1. A multiplicity of contacts is preferable to a single contact in a microphone. 2. The multiple contacts in a microphone should be arranged in multiple arc and not in series. The reason of this is that in the former case the currents are comparatively small; since the total current is subdivided between the different contacts; and that the variations of resistance are relatively greater with weak than with strong currents. 3. The movable carbon should be heavy, in order that it may have a great moment of inertia; but at the same time the pressure should be small; since with a large moment of inertia in the movable carbon the maximum variation of pressure will be obtained, and the variation of resistance will be greater as the initial pressure is smaller. 4. The resistance of the microphonic system should be small, for the lower it is the greater are its variations relatively to the initial resistance. 5. The current traversing the microphonic contact should be as strong as possible under the given conditions.

The Vienna Electrical Laboratory.—The programme of this undertaking has just been issued by the Directors of the Technological Museum, of which the

laboratory forms a recently added section. The work will be superintended by Herr Carl Schlenk, and is to embrace experimental investigations of dynamos as regards output, power consumed, efficiency, and other matters; investigations and reports on executed installations for lighting, power, or chemical purposes, photometry of arc and glow lamps, calibration of measuring instruments, and investigations of primary and secondary batteries. A tariff has been fixed for the work, which will presumably be required very frequently. Thus for testing a dynamo the charge will be from £1. 4s. to £4, according to size of machine; for testing a glow lamp, 16s. to £1. 4s.; arc lamp, £1. 4s. to £1. 12s.; calibration of instruments, 5s. to £1. 12s. Members of the museum obtain a discount of 25 per cent off these charges. Where the work is of special nature, or for outside work, the charge is to be agreed upon beforehand. These fees are levied primarily with the object of covering working expenses. Any surplus is to be equally divided between the exchequer of the museum and the staff of the laboratory.—*Industries.*

Michigan.—Arrangements are now nearly completed for the organisation of a company and the construction and operation of a Van Depoele electric road between Detroit and Mount Clemens, the seat of the famous mineral springs and quite a famous resort for invalids from all parts of the country. Mr. Willis C. Turner, of the Van Depoele Construction Company, is at the bottom of this enterprise. The length of the projected line is 20 miles. It is proposed to locate a central station about midway between the two terminal points, at which the motive power for the entire system will be generated. There will be three electric motors of 50 h.-p. each, a 200 h.-p. generator with boiler and engines commensurate, and $20,000 worth of half-inch copper wire conductors. It is proposed to have three closed cars, Pullman-built, 30ft. long, and three open cars for summer running, each 40ft. long, with seating capacity for 100 persons. One train will leave Mount Clemens every hour and another Detroit at the same time; and, though stopping at several hamlets *en route*, it is believed that the round trip can be made in two hours. One train will be held in reserve for excursions or emergencies. Light freight, baggage, and mail will be carried in addition to passengers. The estimated cost of the entire line, fully equipped, is $250,000.

Acheson's Thermo-electric Generator.—In this thermo-couple one of the elements is in the form of a tube enclosing the other element; the space between them being occupied either by a fluid in motion or by a substance which, when heated, evolves a gas. The tubular element is heated, and the circuit is completed by bringing into contact with it the coolest portion of the interior element. The fluid in motion may be water; the substance evolving a gas (conductive at a high temperature) may be binoxide of manganese. The idea is ingenious, and the plan suggested certainly allows of a high temperature-difference. No information, however, is given as to the potential-difference obtained; and we think there are two conditions which would be operative in preventing the arrangement from being utilised in practice as a source of electrical supply. One is the comparatively high resistance of the heated fluid or gas, and the other is the alteration of the elements by chemical action. This would probably be greater in the case of the fluid than in the case of the gas; since in the former the passage of electricity can only take place by electrolysis. Still there is here a germ idea that may be developed, and become of importance in relation to a question—that of cheap electrical supply—which is of interest to all electricians.

New Process of Nickel Plating.—The solution invented by M. M.-J. Arène, the French vice-consul at Mons, is composed of the following ingredients:—

Pure sulphate of nickel	1 kilo.
Neutral ammonic tartrate	725 grams.
Tannic acid obtained by the ether process	5 ,,
Water..	20 kilos.

The ammonic tartrate is obtained by saturating with ammonia a solution of tartaric acid. The nickel sulphate should be carefully neutralised. The ingredients are first dissolved in three or four litres of water; the solution is then boiled for about a quarter of an hour, water is added to make up the 20 litres, and the solution is filtered. The bath may be renewed indefinitely by the addition of the same substances in the same proportions This solution, which is now employed at several of the nickel-plating establishments in Hainaut, allows of the deposition on all metals, by means of a comparatively small voltaic current, of a thick deposit of nickel. The deposit obtained is white, soft, homogeneous and, even when of considerable thickness, free from roughness. No scaling occurs if the objects to be coated have been properly scratch-brushed and cleansed. The cost of nickel deposition with this solution is said to be but little higher than that of electro-coppering.

Self-Luminous Buoy.—Mr. G. M. Hopkins, in the *Scientific American*, says:—"Among the tried devices for rendering buoys luminous are lamps arranged to burn for a long time, phosphorescent mixtures, electric illuminators supplied with the current from the shore by means of a cable, and the more recent luminous paint, which absorbs light by day and gives it out at night. Compressed gas has been employed with great success, some of the buoys having been designed to carry six months' supply of gas and to serve as lightships. An apparatus has been designed as an auxiliary to bell buoys and whistling buoys. It is based upon the generation of electricity by the agitation of mercury in a high vacuum or in gas of high tension. The self-exciting Geissler tube involves the same principle. The buoy is adapted to ring a bell by the rolling motion imparted to it by the waves. Advantage is taken of this motion to agitate mercury in annular tubes placed in the upper portion of the frame of the buoy. The tubes are made very heavy and strong, and each contains barriers for causing friction of the mercury against the sides of the tubes. To insure the action of one or more of the tubes at all times, they are inclined at different angles. A slight motion of the buoy causes the mercury to travel circularly in the tubes and generate sufficient electricity to render the tubes luminous."

The Telephone from Paris to Marseilles.—A telephone line is about to be constructed between these two cities. Before deciding upon this undertaking, it was considered necessary to carry out some experiments in long distance telephony, which are of considerable interest, even at the present time. As no single stretch of wire could be found, at least in Europe, extending over 900 or 1,000 kilometers, a line from Antwerp to Brussels was connected with one from Brussels to Paris, this being connected with another line from Paris to Brussels *viâ* Momignies, which, again, was connected with a line from Brussels to Verviers. The total length of line thus included between Antwerp and Verviers was about 1,000 kilometers. Through this distance communications were heard with the

greatest ease. The sound of the voice was clear and distinct, and was heard as well as it is through the present line between Brussels and Paris, on which the results are excellent. The work in connection with the Paris-Marseilles line is to be actively pushed forward; at certain points they have already been commenced. The conductors, of silicated bronze, are to be underground as far as Nogent-sur-Marne, being laid in the Paris and Vincennes drains. From that point they are to be overhead, and will follow the line of the railway. It is hoped that the line will be opened to the public about the month of July next.

Catching a Milk Thief.—The Boston *Herald* tells the following story :—"One of the members of the police force of this city is a thorough electrician, and when off duty is constantly experimenting with captive lightning. He has his residence at the south end wired from attic to cellar, and makes the electric fluid do all that it is capable of therein. For the last few days his milk has been stolen, can and all. He made up his mind that the thief must be captured, and called to his aid his favourite electrical appliances. The milkman had been in the habit of leaving the lacteal fluid on a little shelf beside the rear door of the house. In order to reach this door it was necessary to pass by the front entrance and go down an alleyway some fifty feet long. Mr. Electrician went to work and connected his wires with the shelf, so arranging the circuit that the removal of the can from its receptacle would strike a gong in the dining-room. Yesterday morning he went home early and took up his position under the gong. Soon he heard the milkman stop and leave the can in its place. He waited patiently for further developments, and just as he was dropping into a doze, zip! whir-r-r! went the gong over his head. To spring from his chair and dart for the front door was but the work of a second, and he landed on the sidewalk at the alleyway entrance in season to nab the marauder, who was coming out with the can in his grasp. He did not take him into custody, but it is fair to assume that there was not dust enough left in the fellow's coat to cause irritation in a midget's optic. The fellow will probably not attempt to purloin that officer's milk for some time to come."

Critical.—The *Journal of Gas Lighting* refers as follows to the data in relation to the economical questions which have been put forward in a pamphlet issued by a certain electric light company :—"As to price, the company profess to charge at the rate of 1s. per Board of Trade standard unit of 1,000 watt-hours, 'which,' they remark, 'is equivalent to a charge of 6s. per 1,000 cubic feet for gas.' Now a nominal 16-candle power incandescent lamp takes a current of 50 watts per hour; and, therefore, at this rate would run 20 hours for a shilling. The same period of supply for a 16-candle gas-burner of the ordinary stamp would require 100 cubic feet of gas, so that the equivalent cost of gas would be 10s., instead of 6s. per 1,000 cubic feet, as stated by the company. Who now is registering 'in favour of the suppliers?' It is admitted that if accumulators are employed, the charge for electricity will be 1s. 6d., instead of 1s. per unit, or an advance of 50 per cent. This does not look very promising for the future of accumulators. Seeing what Mr. Offor has to say about the absolute necessity for accumulators, it is rather strange that this company, prepared, as they pretend, to do business on a grand scale, can find it possible to tell their patrons that 'it was once a matter of general opinion, though one from which the experience at Eastbourne and Brighton causes the directors of this company to dissent, that no electric light distribution scheme is perfect unless it embraces accumulators,' and to declare that these appliances 'add a great item of expense in the production of light, as they only give back in actual working about 70 per cent. of the work put into them, and their first cost and cost of maintenance are both heavy.'"

Miners' Lamps.—We are glad to see that many of the local papers are taking up the question of electric miners' lamps with energy. The *Cardiff Times*, for example, has a long illustrated description of the Swan lamps used in the Rhondda, which commences with the following paragraph :—"The Davy and the Clanny lamps which have, unquestionably, made the names of their inventors famous, are now doomed. The lamp of the future is the electric. It is with great reluctance that many a miner parts with his Clanny. Having worked for twenty or thirty years with it, having entered working places where the atmosphere was foul and returned in safety, being able to detect on the instant, by its means, the slightest accumulation of explosive mixture, he is naturally under the impression that practically no better lamp is required to enable the miner to pursue his arduous and dangerous calling. But even miners' lamps come under the Darwinian theory of the survival of the fittest. A number of electric lamps have for some months past been used at the Ocean Collieries. About 200 are in use at the National Colliery, Cwtch, where the recent terrible explosion occurred, and 600 more have been ordered. Eight hundred similar lamps (Edison and Swan's) have also been ordered by the same proprietors, Messrs. Ward, Watts, and Co., for their colliery at Blaen-Rhondda, and 1,600 more for two collieries in other districts. Few, indeed, were there who anticipated so marvellous a development of this subject when, some four years ago, Mr. David Evans, Bodringallt, manager of the Ferndale and Bodringallt Collieries, had a certain memorable interview with Prof. Abel. It appears that the first miner's electric lamp invented required wires to be carried from the source of electricity along the workings and attached to each lamp. Mr. Evans observed to the professor that such lamps would never come into general use, as the wires would be occasionally broken by falls. 'To render any kind of lamp practicable,' remarked Mr. Evans, 'it must, at all events, be portable.' 'Well,' replied the professor, 'that's impossible. It can never be made.' 'But you see,' said Mr. Evans to me, 'the professor was wrong. We have had portable electric lamps. I believe myself that the electric is the lamp of the future. The Clanny and the Davy have seen their day.' 'Why didn't you go in for electric lamps?' I inquired. 'Well,' replied he, 'We'll wait a bit. We keep watching how things go on.'"

Taunton.—A correspondent to a local paper, discussing electric lighting, says :—"The electric light is so much appreciated in our town that there is little doubt that, notwithstanding the small extra cost, it will before long be extended to the whole borough. There is no disguising the fact that nothing that has been done of late years has so much conduced to the prosperity of Taunton as the introduction of the electric light." Another correspondent writes :—"In your last issue I see there is a letter from a 'Looker On,' in which he quite agrees with me that electrical traction would be an additional attraction to the visitors, but he at the same time seems to be rather doubtful about its usefulness. He then tries to show, by an absurd and at the same time amusing way of arguing, that the Town Commissioners are anybody but the right persons to do *their own lighting*. He talks in a vague sort of way

about the electrical engineers getting all their experiments carried out at the expense of the well-plucked ratepayer, but, unfortunately, he does not tell us either what these experiments are or where or when they are to be carried out. Does he refer to the testing of the dynamo, or to the testing of the lamps? If so, I may tell him that this is generally done before they leave the electrical works. 'Looker On' cannot have been watching the progress of electrical engineering in general and electric lighting in particular as much as his *nom de plume* would suggest, or else he ought to know that electric lighting has been placed beyond an experimental basis for some time past. It is eight years ago now since the Corporation of Blackpool lighted their esplanade, and at a public meeting last year they expressed themselves satisfied with the results. 'Looker On' should note that the Blackpool Corporation supply the electricity from their own plant. There are at the present time 236 companies, and over 25,165 arc lamps in use, in the United States, lighted by one system alone. As regards electrical traction, there are nine electrical tramways in Europe which have been working for more than three years, and there are thirteen working in America, besides many more which are in course of construction; and it is a means of traction which has been proved many times to be cheaper than horse traction. It would appear to me that since the private companies have to make a profit on the lighting of the town, the town commissioners could do the lighting of the town cheaper by having their own plant. It is evident that the shrewd Yorkshire folk, as represented by Bradford, take this view."

The Treatment of Antimony Ores by Electrolysis.—It has been proposed to apply on a large scale for the extraction of antimony from its ores, the process of analysis suggested by Classen, and based upon the separation of antimony dissolved in a solution containing sodium sulphide. Any compound of antimony capable of dissolving in such a solution may be employed; but it is important that there should not be a preponderance of either sodium or sulphur in the material to be treated, for an excess of the former increases the electrical resistance, whilst an excess of the latter produces a precipitation of sulphur. The mixture corresponding to the formula

$$\underset{\text{of antimony}}{\underset{\text{Sulphide}}{Sb_2\,S_3}} \quad + \quad \underset{\text{of sodium}}{\underset{\text{Sulphide}}{Na_2\,S}} \quad + \quad \underset{\text{hydrate}}{\underset{\text{Sodic}}{2\,Na\,HO}}$$

would be that best adapted for treatment were it not for its instability; it may be approximated to by employing a high proportion of sodium. The sulphide ores of antimony, containing $Sb_2\,S_3$, are well adapted for electrolytic treatment, even when they are poor, since the metallic compound readily dissolves in the sodium sulphide solution even when very dilute. After the solution has been brought to 12degs. Baumé, about 3 per cent. of its weight of sodic-chloride is added to it in order to increase its electrical conductivity, and it is run into iron tanks which may be employed as cathodes. The anodes are of lead, and the E.M.F. of the current is from 2 to 2·5 volts per tank. The antimony becomes deposited either in powder or in brilliant scales. After it has been collected, it is washed in the first place with water, to which a little sodium-sulphide or hydrate, or ammonia, has been added, then with pure water, next with water slightly acidulated with hydrochloric acid, and lastly with pure water, after which it is dried and melted. In a first experiment, with 9·62 kilos. of sulphantimoniate of sodium and 8 kilos. of sodic-hydrate, 2·437 kilos. of antimony were obtained out of a total quantity of 2·440 kilos. The mother liquor contained 2·4 kilos. of sulphydrate of sodium (NaHS), 1·2 kilos. of sulphide of sodium (Na_2S_2), and 1·5 kilos. of thiosulphate of sodium ($Na_2S_2O_3$, $5H_2O$). In another trial, with 3·4 kilos. of antimony sulphide and 7·2 kilos. of sodium sulphide, the loss was 5 grams on 2·4 kilos. of antimony; the mother liquor in this case contained 1·3 kilo. of sulphydrate, 1·2 kilo. of sulphide, and 1·6 kilo. of thiosulphate of sodium. The reactions occurring respectively at the anode and at the cathode are indicated by the following equations:—

$$6NaHS + 3O = 3H_2O + 3Na_2S_2$$

and $$Sb_2S_3 + 3Na_2S + 6H = Sb_2 + 6NaHS.$$

The Impending Cable Compromise.—The *Financial News* says:—"The public have become so familiar with a state of war among the cable companies that it seems to be difficult for them to realise the possibility of its coming to an end. But, as we explained on Saturday, it has for several months been evident to the initiated than an early compromise was inevitable. The information we have published from New York came to us from a very reliable source, and we have no doubt that its accuracy will be demonstrated within a very short time. It is probable, indeed, that the chairman of the Anglo-American Telegraph Company may have some communication to make on the subject at the approaching half-yearly meeting of shareholders. Meanwhile, we are assurred that the negotiations, if not actually completed, are on the eve of completion. The point which it has been found most difficult to agree about is the new rate, certain members of the pool being in favour of 1s. 3d. or 1s. 8d. per word, while others are for the plain and simple shilling. In August last a correspondent of the *Statist*, in advocating mutual concessions between the cable companies, made a very striking exhibit of the good effects which even a moderate advance of tariff would produce. He showed that a 1s. 3d. rate would pay 4 per cent. on Ordinary, 6 per cent. on Preference, and 2 per cent. on Deferred, while a 1s. 8d. rate would yield 6 per cent. all round. The following were his calculations:—

Per Last Half-yearly Report.

Gross receipts of 6d. per word		£94,000
General working expenses		39,000
Surplus		55,000
If rate 1s. 8d. is proposed, result would be gross	£13,000	
Deduct for less wires consequent on higher rates, say 25 per cent	78,250	
		234,750
Working expenses		39,000
		195,750
Half-year's interest on reserve £1,000,000		17,000
		213,250
Dividend at 6 per cent. for six months on £7,000,000		210,000
If rate 1s. 3d. per word, result, say	235,000	
Deduct for less wires consequent on higher rate, say 20 per cent	47,000	
		188,000
Interest on reserve		17,500
		205,500
Working expenses		39,000
		166,500
Dividend at 4 per cent on Ordinary, 6 per cent. on Preference, and 2 per cent. on Deferred for half-year		£140,000

CONSTANT PRESSURE IN ELECTRIC TOWN MAINS.

I.

The first condition in any system of public supply of electricity is that the lamps or motors installed should be perfectly independent of each other. The householder naturally demands that he should be able to switch on one or more lamps at any hour of the day or night, and that whatever may be the number of lamps in use in his own or other houses each individual lamp should always give the same amount of light. The simplest plan to make the lamps independent of each other is to put them in parallel circuit; but then the difficulty arises that those lamps which are farthest from the centre of supply must at those times when a large amount of current is consumed give a somewhat less brilliant light than is the case when only little current is consumed throughout the district. To obtain absolute constancy of light is a physical impossibility, for this would require mains of no resistance; but we can, with a judicious arrangement of conductors, reduce the variations of pressure within such limits that the light of each lamp may be considered as sufficiently constant for all practical purposes. That a certain variation of pressure is unavoidable, has been recognised even in the early days of electric lighting when speculators and company-mongers pretended to be in a position to entirely supplant gas by some special system of electric lighting, and a certain limit of variation in the pressure has been fixed by the Board of Trade rules. The limit, it is needless to say, was not fixed arbitrarily, but on the recommendation of scientific witnesses called before a Parliamentary Committee, and in this as in many other things the witnesses were wrong. To allow, as the Board of Trade rules did, the pressure to rise 5 per cent. above and to fall 5 per cent. below the standard would be absolutely fatal to the electric light, for no householder would submit to the corresponding variation in the amount of light supplied. It must be remembered that the light intensity of a glow lamp does not vary directly as the potential difference at the terminals, but in a much greater ratio. If the resistance of the carbon filament were independent of the current the energy consumed in the lamp would vary as the square of the pressure and the light emitted would vary in a slightly higher ratio. But the resistance of the filament is not a constant. It becomes lower as the current increases, and, therefore, the variation of light is considerably greater than the ratio of the square of the minimum and maximum pressure. The exact relation between pressure and light is a very complicated one, and is different with different lamps, but for comparatively narrow limits on either side of the standard pressure we may reckon that the light varies as the pressure to the power 2·5. Thus if 100 volts be the standard pressure and 105 the maximum, according to the original Board of Trade rule, the light would increase by about 13 per cent., whilst a drop in pressure of 5 volts would diminish the light by about 14½ per cent. Were such a variation of pressure allowed a 16-candle lamp would occasionally give a light of 18·1 candles, and at other times of only 13·7 candles, a variation quite inadmissible, to say nothing of the further drawback of variations in the colour of the light. This would be either brilliant white or reddish yellow accordingly as the pressure is a maximum or a minimum. The limit of 5 volts out of 100 up and down is, therefore, by far too wide, and to obtain a really serviceable supply we would have to arrange our mains so that the pressure could never exceed, say, 1½ volts above, or fall more than 1½ volts short of the 100 volt standard. Under these circumstances the light of a 16-candle lamp would vary between 16·58 and 15·36 candles, a variation probably smaller than that continually taking place in our gaslights where a very sensitive regulator is not employed to keep the gas pressure constant.

Having thus fixed the limits within which the potential difference may rise and fall, as the demand for current varies in different points of the district and at different times, the question arises as to the best way of laying down the mains so that these limits should not be exceeded. There is, however, also another consideration, which must influence the calculation for the size of mains, viz., that of economy. Every conductor from the single lamp wire to the heaviest underground cable must waste a certain amount of energy by the resistance it opposes to the passage of the current. This energy must be supplied by the dynamos at the central station in addition to that consumed by the lamps, and has ultimately to be paid for in the shape of an increased coal bill. Now to keep down the energy thus wasted and the corresponding cost of fuel, water, oil, &c., we should employ conductors of very low resistance—that is to say, of large cross section, but in doing so we increase the annual charges on the system in another way. To draw up a proper balance-sheet of the cost of supplying electricity from a central station we must obviously include the item of interest on the capital outlay and the depreciation of plant. The revenue derived from the sale of current to the subscribers must cover these items, the working expenses, and should leave a balance by way of profit on the undertaking, and in some cases also provide for a sinking fund. By employing lighter mains we diminish the items of interest, sinking fund, and depreciation, but we increase that of working expenses, and to a certain extent also that of capital outlay on the generating plant at the central station, since owing to the greater waste of energy in the mains, more steam and dynamo power is required. On the other hand, if we wish to economise power, both in the first outlay for boilers, engines, and dynamos, and in the annual working expenses, we must take care to waste as little as possible in the mains—that is to say, we must make them very heavy. But in taking this course we burden the installation with a heavy charge for interest on the value of copper put into the ground. By going to extremes in this direction, it is quite possible that, after paying off interest, no profit is left; whilst if we go to extremes in the other direction by stinting the mains, it may happen that the working expenses and interest on the plant at the station will absorb all the revenue, and again no profit will be left. It is evident that between these two extremes there must be one particular size for each main, which, taking all things into consideration, is most economical—that is to say, will leave the largest margin of profit out of a given revenue. Sir William Thomson has proved that for a single pair of mains, having to carry a constant current, the most economical section is that for which the interest and depreciation equals the annual cost of the power wasted; but when we have to deal with a complicated network of mains, where the current is by no means constant, and where the maximum current only flows for a few hours per day, as must necessarily be the case in a system of general supply, the calculation of the most economical section of conductor becomes extremely complicated. If it were only a question of current variation in a single pair of conductors we could deal with it in a fairly satisfactory manner as has been shown by Prof. Forbes in his cantor lectures before the Society of Arts. For instance, if the full current only flows for four hours per day, and if during the rest of the time the demand varies to ¾, ½, ¼ current, and no current at all, the most economical section of conductor will be about one-half that which would be required were the full current always flowing, the exact ratio being determined by the proportion between the different currents flowing at every hour of the day. But in practice we are seldom in a position to predetermine with anything like accuracy the shifting and changing of the demand for current throughout a district, and therefore only an approximate solution of the problem is possible. Reduced to its simplest form, the problem is to determine what pressure should be lost in the mains when the full supply is on, to insure, all things considered, a maximum of profit on the invested capital. We do not propose to further discuss this question at the present time, but may mention that in a number of central stations, with which we are acquainted, the loss on a 100 or 110-volt service varies at full supply between 10 and about 25 volts, and as these stations are paying concerns, we may take it that a loss of about 20 volts on a 100-volt distribution will, under ordinary circumstances, be the most economical.

In the beginning of this article we have said that subscribers would not tolerate a larger variation than about 1½ volts up and down from the 100-volt standard, and our readers will probably ask how we can reconcile with this

statement the result now arrived at, according to which the loss of pressure should be as much as 20 volts. The contradiction is, however, only apparent and not real; for the small loss refers to those mains only to which the house services are directly connected, whilst the large loss refers to mains which are not tapped by house wires at all, and only serve to feed the distributing network of mains at certain points. In laying down these feeders we are untrammelled by the condition of constancy of pressure along the whole of their length, and can therefore determine the size strictly in accordance with economic principles; whereas in the network the question of the most economical section must be set aside for that of constancy of pressure, without which householders would refuse to have the electric light at any price. Thus, we see that the distributing plant is naturally divided into two portions—one in which constancy of pressure is the first and absolutely essential condition, and the other in which a large variation of pressure may take place, provided economy in working is assured. The former we call the network and the latter the feeders. To make the distinction between the two clear, we shall assume, by way of illustration, that we have to light a straight street 400 yards long, the central station being at one end. Let there be three lights per yard of frontage on each side of the street, or 2,400 lights fixed. Of this number probably only one-half will be simultaneously alight, so that the station even in the busiest hours of the evening will have to send out current for the supply of only 1,200 lamps. At 60 watts per lamp and 100 volts pressure a current of 720 amperes would therefore be required. If the station be connected directly with the main—that is, without the intervention of feeders tapping the main at different points, the whole current enters at the station end, but as current is taken off at every house the current flowing in the main will gradually diminish towards the far end. If the current taken off per yard run is constant throughout the length of the street, the difference of pressure between the ends is, according to a well-known law, approximately half that which would obtain if the whole current were taken off at the far end. Now, at the full supply, the difference of pressure will be a maximum, and in the daytime, when very few lamps are alight, it will be nearly zero. If the lamps were all standardised to exactly 100 volts, then 101·5 and 98·5 volts would be the highest and lowest limits of pressure on any point of the main. In other words, the total loss of pressure at full supply must not exceed 3 volts. In this case the pressure at the station would have to be 101·5 volts for full supply, and anything between 100 and 98·5 volts at minimum supply. This margin of 3 volts is very small, and would require an almost prohibitive amount of copper in the main. Let us, then, see how we can increase the margin and reduce the weight of copper. One method which immediately suggests itself is to employ lamps of slightly different voltage. Say we take lamps graded into half volts from 101·5 down to 98·5 and fix them according to their voltage, those of 101·5 volts nearest the station, those of 101 volts a little further on, those of 100·5 volts still further, and so on, till we come to the lowest volt lamps, which would be fixed at the end of the main. We can now keep the pressure at the station at 103 volts for the full supply, and allow a loss of 6 volts in the main. The nearest lamps would be overstrained by $1\frac{1}{2}$ volts, and the farthest lamps would get $1\frac{1}{2}$ volts too little pressure when the full supply is on; whilst when running light we would keep 100 volts at the station and overstrain the farthest lamps by nearly $1\frac{1}{2}$ volts, the nearest lamps getting $1\frac{1}{2}$ volts too little pressure. This, then, is the best we can do under the given condition. The resistance of the main must be such that when the whole current is sent round it, that is 400 yards out and 400 yards home without intermediate cross connections, a pressure equal to twice the permissible loss (or, say 12 volts) is required. The resistance of 800 yards of single main must therefore be

$$\frac{12}{720} = \cdot 0167,$$

or ·00208 ohms per 100 yards. With copper of 98 per cent. conductivity a sectional area of 1·19 square inch would be required, and the weight of copper in the main would be about 4·85 tons, being at the rate of $4\frac{1}{2}$lb. per lamp fixed.

Now, if it had been possible to place the station *into* the centre of the street, the distance of the farthest lamp would be half that of the previous case, and only half the current would be sent into each of the mains on either side of the station. This would at once enable us to reduce the cross section of the conductor to one-quarter of its previous dimension, and the weight of copper in the mains would come out at only a little over 1lb. per lamp fixed. But since we cannot shift the station from the end of the street to the middle we must do the next best thing, viz., lay a separate feeder from the station to the centre of the street, and disconnect the main from the dynamo at the station. For the 200 yards of main which lie between the station and the feeding centre, the current will then have to traverse a greater length of conductors than before (running out on the feeder and back on the main), and it might appear as if on this account the arrangement must be bad. But in reality this is not so, for the loss of pressure on the feeder may be anything we choose to make it without in the slightest degree interfering with the constancy of pressure on the main. Thus, if we assume that with full work the feeder may lose 20 volts, its resistance in the 200 yards out and 200 yards home would have to be $\frac{20}{720} = \cdot 02775$, or ·00693 ohms per 100 yards. Its area would be ·36 square inch, and the total weight of copper in the feeder would be about $14\frac{3}{4}$cwt., or at the rate of ·69lb. of copper per lamp fixed, which added to the weight of copper in the main, brings the total up to 1·82lb. per lamp fixed. Thus we see that, whereas $4\frac{1}{2}$lb. of copper were required per lamp when the end of the main was directly connected to the station, only a little over $1\frac{3}{4}$lb. is required where the connection is by means of a feeder to the centre of the main. Now, if one feeder produces such a saving it is reasonable to suppose two feeders will still further economise copper. Let us see. Suppose we lay one feeder to a point on the main 100 yards from the station and the other to a point 300 yards from the station, and consequently 100 yards from the far end. Each feeder will now supply 200 yards of main, and carry a current of 360 amperes when the full supply is on. We have now again halved the current in the main and halved the distance of the farthest lamp; consequently, with the given loss of 6 volts, we can employ a main of only one quarter the cross-section. The weight of copper in the main will therefore now only be ·285lb. per lamp fixed. If a pressure of 20 volts is to be lost in the feeders, we find that the longer of the two must contain 1,860lb. of copper and the shorter 210lb., making in all for the feeders 2070lb., or ·865lb. of copper per lamp fixed. The total weight of copper in the distributing plant comes therefore to 1·15lb. per lamp fixed. Taking as our standard of comparison the weight of copper required in the case where the main is directly connected to the station, we thus find that we require

With one feeder ... 40·5 per cent. of this quantity of copper.
With two feeders... 25·6 ,, ,, ,,

The advantage of the feeder system is thus made apparent at a glance, but in order that the distribution may be equally perfect in the case where we supply not only a single main, but a complicated network of mains by means of feeders, it is necessary that the pressure at the feeding centres should be perfectly under the control of the engineer at the station, and we shall deal with this part of the subject in our next issue.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY B.SC., F.R.S.E.

The object of this series of articles on "elementary testing" is to describe in as simple a manner as possible the methods of making, and the instruments used for, the tests which are usually required by those engaged in making installations of electric light or of electric power. Electrical testing, as the making of a certain class of electrical measurements is often called, has generally been treated

with a view to its applications in telegraphy, and, indeed, the whole subject has been developed because systematic testing is essential to the telegraph engineer. Since the application of electricity to the production of light and of power, has become an important branch of industry, many measurements which were not required in the telegraphic application have become essential. There are, of course, a great many of the measurements in common use by the telegraph engineer which are necessary for safe and successful practice in electric lighting, and thus to a large extent the tests given in these articles will be the same as those given in standard works on "telegraph testing." This applies particularly to the part of our subject which is to come first—namely, the tests required during the wiring of an installation; the tests for the quality of conductors and insulators; the measurement of the resistances of the coils of different parts of dynamos, motors, transformers, &c.; the tests for the degree of perfection of the insulation of the different turns of the coils from each other, and of the whole from the bobbin in which it is wound, and so on.

The methods of making the different tests will be described and illustrated, where necessary, by simple diagrams, any peculiarity in the apparatus required being, if necessary, referred to at the same time. The detailed descriptions of the various forms of instruments that seem most suitable for the purpose will, however, be given in a collected form after the more elementary part of the subject has been treated. The tests given in the present article are for the most part of a purely qualitative character. They are convenient sometimes, as they show whether there is any bad fault, but it must be clearly understood that they should only be used *during* construction or preliminary to a more systematic series of measurements.

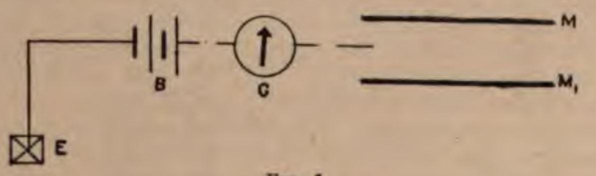


FIG. 1.

Consider first an installation wired, let us suppose, for incandescent lighting on the parallel or multiple arc system. Such a system consists essentially of two leads run parallel to each other throughout the whole installation. In actual practice it consists of one or more pairs of main leads, from which pairs of branch leads are run to the different parts of the system. These branch leads, or systems of leads, are usually connected to the mains through switches and fuses, and so also in some cases are the sub-branches connected to them. This gives rise to a more or less complex system of connection, and hence to considerable chances of accidental breaks and other faults in the circuit. That all the connections have been made up to any point in the system may be quickly tested as follows:—First, test whether the two main leads, each with its system of branches, is insulated from earth. Second, test whether the two mains and their branches are insulated from each other. Third, test, by putting a bridge across the mains or pair of branch mains, whether there is a circuit. These three tests, the third being applied to all the systems of branches, are sufficient to show whether the connections are complete all through the installation up to any point in its progress. They may be made in the following manner:—

1. *Insulation of main leads.*—Connect, as shown in the diagram, Fig. 1, one pole of any convenient battery, B, of one or more cells to one of the terminals of a galvanometer or "detector," G, and the other pole to earth, say through a water pipe or a metal plate, E, in contact with damp earth. Observe whether any deflection is produced on the galvanometer, G, when it is put in contact with the mains M or M_1. If the work has been systematically carried through, this test will almost to a certainty give a negative result. It is of great importance, especially in large installations containing a multiplicity of branches, that the insulation of the leads from earth and from each other should be regularly tested as the work progresses, because a breakdown of insulation is somewhat troublesome to localise. Assuming for the present that the insulation is found to be perfect, we come to—

2. *Insulation from lead to lead.*—Referring to Fig 1, disconnect the battery from earth and connect it to one of the mains M or M_1, and observe whether *no* deflection is produced when the free electrode of the galvanometer is connected to the other main. Having made sure by this test that the whole system of leads is, so far as this rough test will show, properly insulated, we come to test 3.

3. *Continuity.*—Connect in succession the ends of the branch leads and observe whether in all cases a *strong* current flows through the galvanometer. This completes the three tests. In the event of a defect being found by any of the three tests, it will generally be possible to find it by simple inspection without having recourse to electrical methods. Methods of localising faults will, however, be given further on in connection with quantitative measurement.

The galvanometer used in these tests need not be of fine construction, but it is convenient to have it roughly graduated and its resistance known, so that its indications give a rough idea of the resistance in the circuit. The resistance of the gavanometer should be moderately high—say, 1,000 ohms, or more—in order that it will give a sensible deflection, even when the insulation is considerable, and should be provided with a controlling magnet powerful enough to bring the deflection within the range of the scale when the battery is short-circuited through it. It is of great importance that both the galvanometer and the battery should be portable, and little likely to get out of order. In order to

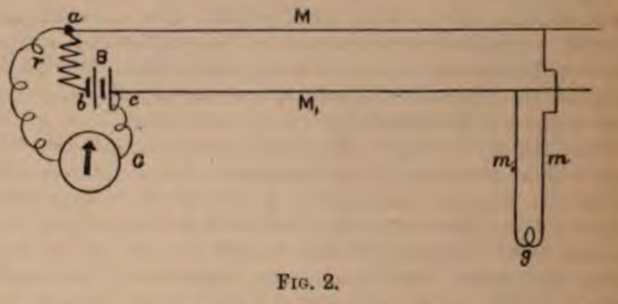


FIG. 2.

make the test roughly quantitative the deflection produced when the two poles of the battery are connected direct to the terminals of the galvanometer should be noted at the beginning of the test, and the deflections, if any, when the insulation tests are being made. Suppose the current produced by the battery joined direct to the galvanometer gives a deflection d, and the leakage current through the insulation gives a deflection d_1. Then, if the graduation is such that the deflections are approximately proportional to the current, and the resistance of the instrument and battery together (practically that of the instrument alone) be called R, we get for the insulation I,

$$I = R\frac{d}{d_1} \text{ approximately.}$$

When an instrument having a resistance as high as is here recommended is used for the third, or continuity test, the deflection should not be appreciably diminished by the introduction of the resistance of the leads, as they would in almost any electric light installation have a resistance only equal to a small fraction of the resistance of the galvanometer. At first sight it would appear that by using a low resistance galvanometer and battery, the method just given of getting an approximation to the insulation of the leads would also serve to indicate whether the resistance of the leads is nearly right, and hence would serve to detect bad contacts due to careless workmanship, bad keys, or bad fuses. The method is not nearly so satisfactory when applied for this purpose, because it is not as a rule convenient to keep a battery of sufficiently low and constant resistance at hand. It entails besides, the use of two galvanometers or of one with both a high and a low resistance coil. The following method of obtaining the required information with the high resistance instrument is much more satisfactory.

Referring to Fig. 2, let M and M_1 be the main leads as before, and let m and m_1 be a pair of branch leads connected

at their ends by a thick wire g. Let the ends of M and M_1 be connected through a resistance r and a battery B, so that a continuous current will flow through the circuit. Join the galvanometer across from a to c, and read the deflection; then move the electrode on c to the end of the resistance at b, and again read the deflection. Let the deflection be d and d_1, as before, and let x be the sum of the resistances of the main and branch leads, and we have approximately, when the resistance of G is great compared with that of the leads or of r,

$$x = r\frac{d}{d_1}.$$

That this equation is true will be readily seen when the following considerations are kept in mind. The same current is flowing through r as is flowing through the leads, and hence the E.M.F. required to send the current through the resistance and through the leads are as r is to x. The deflections of the galvanometer are as the E.M.F.'s on its terminals, or $\frac{d}{d_1} = \frac{x}{r}$, which is the equation given above. The presence or absence of bad contacts in the circuit can readily be inferred from the value of x and the known length and resistance of the leading wires. Should the test indicate a faulty place, it may be found by applying the terminals of the galvanometer to the two sides of the joints, switches, &c., in succession, until the faulty one is found. The method of measuring resistances here indicated was given by Sir William Thomson, and is commonly known as Thomson's potential method. We shall have several examples of its usefulness in the course of these articles. The galvanometer is used to measure the difference of potential between the ends of the resistances, and hence must have sufficient resistance to prevent its application from sensibly altering that difference of potential.

The three tests here given are generally sufficient to insure good workmanship so far as the wiring of the installation is concerned, and if they are properly attended to there is very little chance that the final tests will show any serious flaw. A similar series of tests should be applied after the lamp holders, switches, fuses, &c., have been fitted. This is of great importance in all cases, but especially so when the electric light fittings are fixed to gasaliers and gas brackets, as is not unfrequently done. The insulator test shows whether all the wires and fittings are properly insulated from the gas-pipes, and the test of the insulator from lead to lead insures that none of the lampholders are short-circuiting the leads. The third test should then be repeated by the method illustrated in Fig. 2, each of the lampholders being short-circuited in succession, so as to insure that the lamp branches have been properly soldered on. This last may seem an unnecessary amount of trouble, but experience shows that faulty connection is not uncommon, especially where the leads are covered and the workmen have the opportunity of simply twisting one wire round the other, and then covering it up from view. It is well that the workmen should understand that bad connections are likely to be discovered, although they may be hid from view. There can hardly be anything more dangerous than bad joints in electric light wires, covered as they often are by inflammable material. The joint heats or, if there is any shaking sparks, and fires are the consequence.

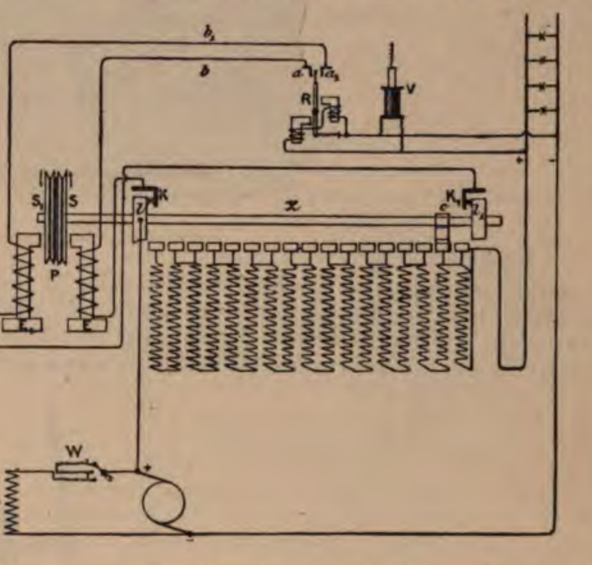
It is convenient to repeat test 3, after all the lamps are hung in position and the keys of them all closed, so as to obtain an approximate idea of the value of the resistance of the lamp circuit for future reference. This is of most use in large factory installations where a considerable number of lamps are turned on by one switch, which entails the trouble of removing all the lamps before a test of the leads can be made. More exact methods of testing working circuits will be given further on, but a test such as here indicated, when made even with comparatively rough apparatus, will often serve the purpose. The insulation of the whole system from earth can of course always be tested, even when the lamps are in position, both leads being taken together. When, however, an earthed return is used, or when, as is sometimes practiced in ship lighting, the ship is used as a return, the insulation test cannot be applied to the whole insulated lead unless the whole of the lamps are either removed or cut out by switches. The insulation test then becomes identical with the test of the insulation between the leads.

(To be continued.)

ELECTRIC LIGHTING OF THE TOWN OF EMS.

Since last spring Ems has had a central electrical station, established by the Spieker Co., which, from certain points of view, is of special interest. From the commencement the installation has worked uninterruptedly, and in a very satisfactory manner.

The two steam-engines employed are high pressure, and each of 70 h.-p.; they are used for driving the dynamos only after dark, being utilised in the daytime in pumping water. Three shunt-wound machines are used, each producing, at 600 revolutions per minute, a potential difference of 230 volts, with a current of 80 amperes. The velocity is maintained sensibly constant by the steam-engine regulators. The three machines can be worked together, connected in parallel, and supply a number of different circuits. The loss of potential is about 15 per cent., *i.e.*, 30 volts. If a single circuit were employed, therefore, the lamps nearest the machines would be worked under an E.M.F. higher by this amount than that of the most distant lamps. The use of lamps varying from 250 to 200 volts



would not meet the difficulty; for the loss of potential would diminish with the number of lamps in circuit. These considerations led the company to adopt seven circuits, each of different length and section. Each circuit itself comprises arc and incandescence lamps, varying in luminous power and in number; their total number is about 885, distributed amongst 40 subscribers. The 10 and 16-candle lamps require a difference of potential of 100 volts, and are arranged two in series. The 30-candle lamps are mounted with two filaments, which together take 200 volts. The conductors are supported by porcelain insulators on posts.

But the interesting feature of the installation is the automatic regulator attached to each circuit, and maintaining a potential difference of 200 volts, whatever may be the external resistance. This apparatus is represented in the above diagram.

Wires from the leads are connected to the relay R, the armature of which, for a normal difference of potential, is held between the two contact-pieces a and a_1. When the potential augments, the magnet attracts the armature, making contact with a_1; when, on the other hand, the potential diminishes, a spring overpowers the magnet, making contact with a. When, therefore, there is a variation from the normal, a current traverses one of the electro-magnets, E and E_1. The plate of iron, P, attached to a rack in connection with the rod z, is thus brought into contact with one of the two pulleys, S and S_1, which revolve in opposite directions. The rod z is thus made to revolve

and to alter the position of the sliding contact, c, introducing more or less resistance in the main circuit until the normal potential difference is restored, the movement of c being limited by the stops, l and l_1. When c reaches either of these, the current is broken at K or K_1.

The electric light is in operation at Ems only during the season—from May to September inclusive.

COX-WALKER'S TELEMETER.

It will be remembered that at the last British Association meeting Mr. Upton read a paper describing Clark's telemeter. Instruments of this kind for indicating the height of water have been used for some years. At the late Newcastle Exhibition Messrs. Cox-Walker exhibited an apparatus which is herewith illustrated, and which is specially suited to indicate the varying height of water in a reservoir, or wherever required.

Fig. 1 shows a central grooved wheel, around which is passed the cord or chain to which the counterweighted float is attached; or, if necessary, a larger grooved wheel may be fixed outside of this apparatus, but connected to it by the universal joint shown in the illustration. Contact levers with spring catches and weighted arms swing on centres as shown. Above these arms are adjustable contact springs, connected respectively with the Zn and Cu of a divided battery, the centre of which is permanently to earth, the levers themselves being connected to line by the terminals as shown (the bottom springs are merely used to steady and check the back-swing of the weighted arms).

On the driving wheel being revolved from left to right, it will be seen that the left-hand lever is raised by the pins in the wheel, and, as soon as freed, the weight causes it to swing into contact with the spring immediately above it, and thus send a negative current over the line to the indicator. When the pinned wheel revolves in the opposite direction the right-hand lever acts similarly, and sends a positive current to line.

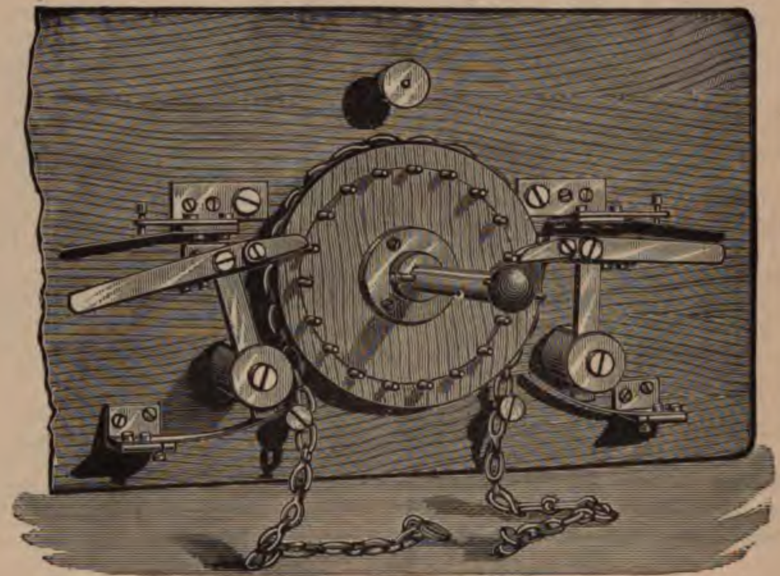


Fig. 1.

The line wire is connected to one of the terminals, L, on the indicator (Fig. 2) and earth to the other terminal E. The current from the contact apparatus always passes through both coils. The pivoted cores carrying the driving anchors, B B, are polarised by means of permanent magnets fixed in the base, and either one or the other is moved in accordance with the nature of the current received.

The driving anchors act separately upon the teeth of the wheels, the anchors and cores being kept permanently in position by means of spiral springs. Bevel gearing, with a crown wheel fixed on the spindle, gives the motion to the index pointer of the dial, indicating a rise or fall in the river, harbour, or tank in which the float may be placed.

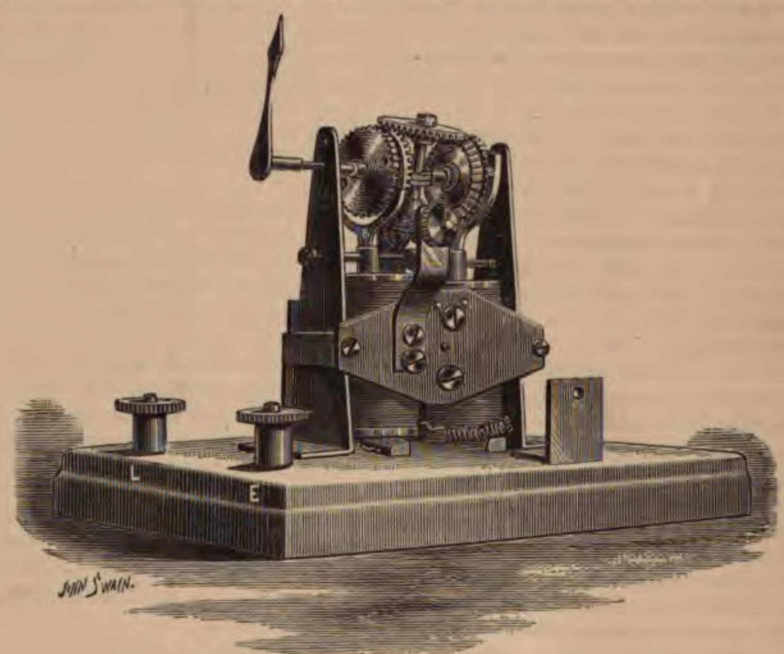


Fig. 2.

Fig. 3 shows the usual method adopted for calling attention to the state of affairs by means of a bell.

It will be seen from these illustrations that Messrs. Cox-Walker have designed a very effective piece of apparatus, and one that should come largely into use.

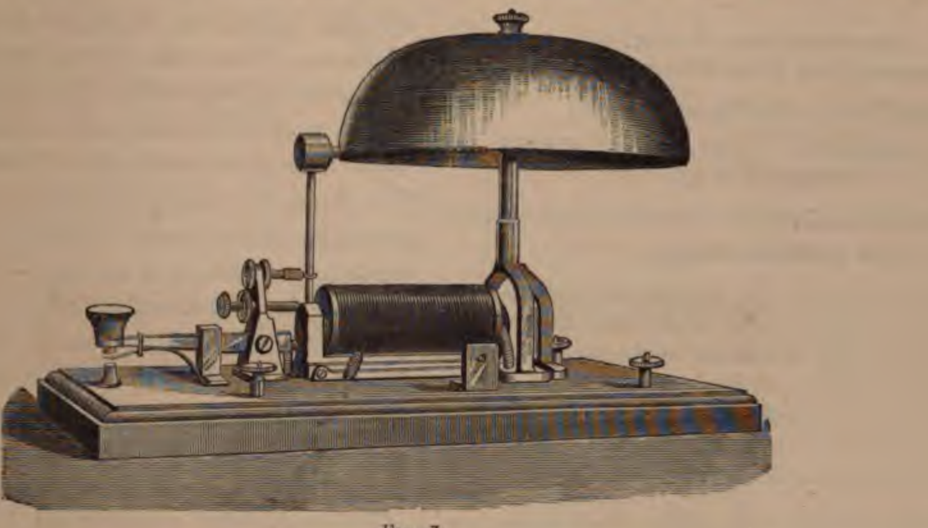


Fig. 3.

MAQUAIRE'S ELECTRO-DYNAMIC BALANCE OR REGULATOR.

In a patent recently issued to M. Maquaire, in France, there is described a system of maintaining a constant current or constant resistance by means of a movement or by means of an equilibrium arrangement. For this purpose the inventor has adapted an arrangement in which the regulating forces employed are exclusively electrical, and which is composed of two distinct parts, viz. :—

1. A sensitive electric motor of which the speed and the direction of rotation are subjected to electric forces solely; and

2. An arrangement for transmission having little passive resistance, and which spreads the work over a long period of time in order to reduce as much as possible the work of the motor during a unit of time.

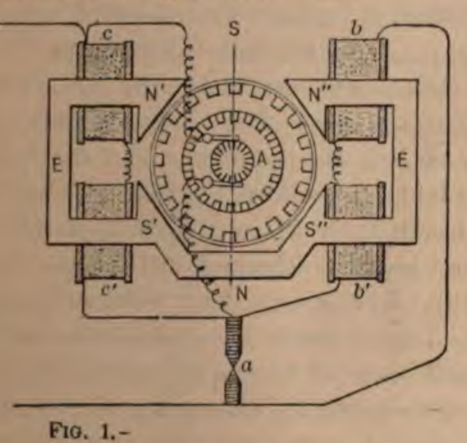


Fig. 1.-

The electric motor which is brought into requisition here is that of Tchikoleff, which, with some changes, is shown in the accompanying illustration, Fig. 1. A is a Pacinotti ring, N S being the polar line, in which the magnetic core may be made of a single piece or of several. Over the winding the armature is covered with an envelope of iron in communication with the magnetic core, which thus gives a more regular and continuous field between the pole pieces and the armature.

As will be seen in the case of the arc regulator, the coils *b b'* are placed in shunt to the arc *a*, and the coils *c c'* are energised by the main current, the armature winding being either in series or in shunt circuit. If the free poles are N' and N'', there are formed two south poles at S' S''; but in this particular case these two latter poles, instead of neutralising each other, act on the ring as if they were free poles. As a fact, when there is an equality of energy in the two coils *b b'* and *c c'*, the poles S' and S'', having equal values, are situated equidistant from the point N. When, on the contrary, the conditions of normal regulation are modified, and the energy, for example, is greater in *b b'* than *c c'*, S'' increases in strength and approaches nearer to S'. From this there results a disturbance of the equilibrium of the pole N and the armature A, which tends to turn in that direction; while, on the other hand, it is attracted in the same direction by the preponderance due to the same cause of the pole N' over the pole N''.

The arrangement shown in Fig. 2 shows the application of the arrangement to a regulator for governing the current from a battery. The current passes into shunt coils *c c'*, and into the armature by the brushes *d d'*, and from there

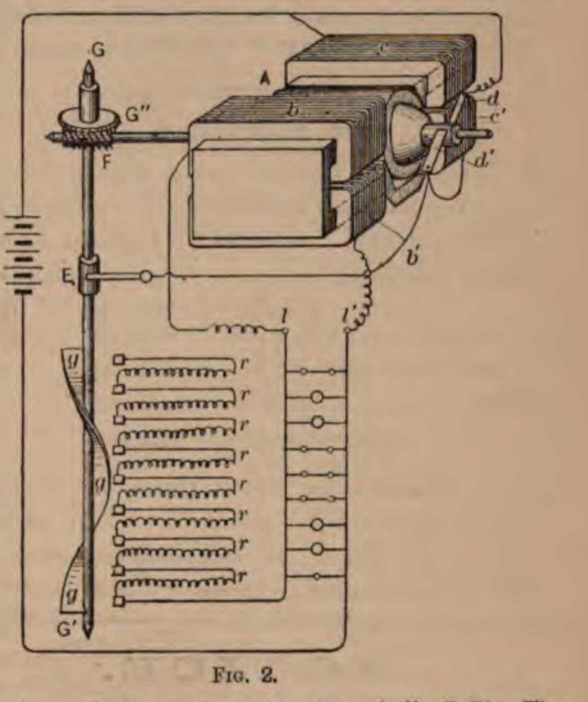


Fig. 2.

to the sleeve E in contact with the spindle G G'. The latter is set in motion by the endless screw F, which is carried by the shaft extended from the armature and which gears with the worm wheel G''. During the movement or rotation of the spindle G G', a helicoidal sheet of metal *g g* touches successively the contacts of a series of resistances *r r* shunted around the line circuit; finally, at the two points of the distributor the current is taken off, which energises the coils *b b'* of the regulator. It will be seen that the electro-dynamic balance is set in motion in one direction or another by the addition or withdrawal of resistance until the strength of the current has obtained a normal value by which the regulator is brought to a standstill. It will be seen that, as shown in Fig. 1, the regulator is designed, among other things, to be used as the regulating mechanism of an arc lamp.

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we issue with this number a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

THE GOVERNMENT AND TELEPHONY.

It needs but a feather to show which way the wind blows, or a sentence to show the direction of the thoughts of the Post Office officials in all that concerns telephony. The reply of the Postmaster-General to the influential deputation that waited on him at Oxley Manor, near Wolverhampton, on Friday last, will afford much room for thought to all interested in telephony. The deputation sought Mr. Raikes to complain of the anomalies to be found in the postal and telegraphic regulations. Among other things the deputation stated that the charge for sending telegrams from post offices through the telephone to their destination was too high. Mr. Raikes in his reply, said: "With respect to the telephone, he agreed that the position of telephoning was unsatisfactory, and was due to various causes. He thought one of the principal causes was the generosity of his predecessor, the late Mr. Fawcett, whose statements had been interpreted in the direction of non-interference with the rights claimed on behalf of the telephone companies. He thought that before long steps must be taken to place telephony on the same footing as telegraphy, under the control of the Government or entirely with private enterprise. He did not think the present system could be justified." We have taken *The Times* report of the deputation, the whole of which will be found in another column, and all that relates to telephony merits instant attention. It is quite clear from what Mr. Raikes said, as well as from what he left unsaid, that practically a determination has been come to to deal with the whole question of telephony. The subject presents two views—the one from a departmental or, better, a public standpoint, the other as its affects shareholders. The ultimate result it is not difficult to foresee. The telephonic as well as the telegraphic service will come wholly under the control of the Government, for under the circumstances no other course is open. The telegraphic service of the country has been acquired at great cost, the returns show that the initial expenditure was too high, and an annual loss is incurred. Telephony, especially as long distance telephony becomes developed, will interfere more and more with telegraphy, the one "will wax the other will wane." The law courts has decided that telephony is a part and parcel of telegraphy, and not something entirely novel—hence the Government will be compelled to take under its control the whole of its purchase. No doubt some hard words will have to be said as to the method of procedure the Government has pursued. The cynic will say great business tact has been shown. Perhaps it has; telegraphy was in the field; the country was almost fully equipped, and naturally the permanent officials desired to economise as far as possible. Hence the determination, we should say, to permit private companies to carry out the larger part of the initial work, and by experience find how to overcome the various difficulties which are always met with in the initial stages of introducing a new application of science.

The private companies have done their share of this initial work and have proved telephony a success. Now the Government will say, we shall assume control of the service, pay you a sum to be determined for your wires and apparatus, probably incorporate the employés as part of the Civil Service, and henceforth carry on the work as a State department. The private companies will not object, except to the price to be paid. The public will refuse to pay one halfpenny for prospective increase of returns, or for money expended in the experimental stage. It will justly be said that the experiments were out of our control, carried on with the facts of the case staring you in the face, were much too costly, and we shall not pay. On the other hand the companies will say theirs is a hard plight. The State would not of itself introduce telephony, would not even prove its practicability; and though the experience gained had been gained at a great cost, those who contributed towards the cost were quite willing so to do, having perfect faith that the returns would be in a very progressive ratio, and in the course of a short time would become so large as to amply repay all initial, even if excessive, expense. At the present moment telephony is, so to speak, "hired out" by the Government, so that two profits have to be paid by the user—the first to the company, the second to the Government. A business nation will not permit such a course to be pursued for many years. The control of the Postal Department is in the hands of some good business men, and there is no doubt that they will object to add to the liabilities of the department by paying, even a small sum, at the present time for patents which will shortly expire. In the ordinary course of business it is pretty easy to foretell that things will be allowed to go on much as they are till the expiration of these patents, when the Government will probably say to the telephone companies, now is the time we shall take this system into our own control. The price to be paid will exclude all consideration of initial cost of the patents to the companies, the argument being that, during the time that the patents have been running, the companies should have made a sufficient sum to have covered all their expenses and given them a handsome profit. It will be seen that there is hardly any means of reconciliation between these opposing interests. It is not the case of ordinary buyer and seller, but a case where the buyer already has a lien upon the property of the sellers.

Since the report of the deputation appeared, an explanation has been given, which shows our contention is probably right, and that there is no intention of Government immediately assuming the direction of telephony.

SAFETY FUSES.

The adjourned discussion on Mr. A. C. Cockburn's paper on safety fuses last week was noticeable for one feature—the unanimity with which speakers condemned the indiscriminate use of "safety fuses." It was agreed —shall we say it is agreed—that the major portion of failures in electric light installations are directly traceable to fuses. Mr. Crompton hit the nail on the head when he admitted the necessity of the use of fuses, and that in order to comply with two antagonistic requirements electrical engineers must compromise in the matter of the position of fuses. Their proper position is at the root of the branch, but if placed in that position they are not within easy reach if anything goes wrong. The discussion witnessed some lively sparring —some speakers maintaining their experience of one and all fuses was that they were utterly unreliable; others as strongly maintaining that their experience pointed to the almost perfect manner in which fuses go off under the appointed circumstances. One gentleman would not trust fuses, but the apparatus which never failed in his hands, or under his observation, was Cunynghame's magnetic cut-out. On the one hand "time" was said to deleteriously affect the fuse, on the other hand "time" was stated to have no bad effect. One set of speakers would not have "lead" or "tin," another stuck to lead or tin; one spoke up for the ordinary wire-shaped form of fuse, others staked their reputation upon "foil." Altogether the important lesson to be learnt from this discussion is that at present upon questions of practice all our doctors differ, and nothing can hardly be more beneficial to the industrial applications of electricity than these discussions from practical men upon such questions. They pave the way towards agreement and uniformity of practice.

DR. WOLLASTON.

William Hyde Wollaston, M.D., F.R.S., was among the most eminent cultivators of science during the early part of this century. He was born on the 6th August, 1766, and took the highest medical degree at Cambridge in 1793, being a student of Caius College. He subsequently commenced practice as a physician at Bury, but not meeting with much success he removed to London, and became a candidate for the appointment of physician at St. George's Hospital, but was unsuccessful. This was fortunate for science, as Dr. Wollaston was led entirely to relinquish the medical profession and to devote his whole energies to the pursuit of science. Dr. Wollaston died December 22, 1828.

Chemistry formed the chief subject of Wollaston's studies. He was the discoverer of two new metals, paladium and rhodium, but he did not confine his investigations to chemistry. His optical inventions alone have rendered the greatest service to both art and science. In 1793 he was a fellow of the Royal Society, of which he became secretary in 1806. For his Bakerian lecture, "On a method of Rendering Platinum Malleable," he was awarded one of the Royal medals.

The particular researches of Wollaston in the domain of electricity are best seen by reference to the memoirs of the Royal Society and in the *Philosophical Magazine*, as well as in the constant references made to his work in the earlier books of the century. Thus, in Dr. Rogets' work issued in 1831, under the auspices of the Library of Useful Knowledge, we find a number of references to Dr. Wollaston. He had devised an elementary galvanic battery, and had improved the construction of the, then, ordinary battery by surrounding each side of the zinc plate by copper. He promulgated original views regarding the electric light, the decomposition of water, the chemical source of electricity and electro-magnetism; and, perhaps with the exception of Sir Humphrey Davy, Wollaston was the most prominent figure in the scientific world at the birth of the 19th century; hence, we feel

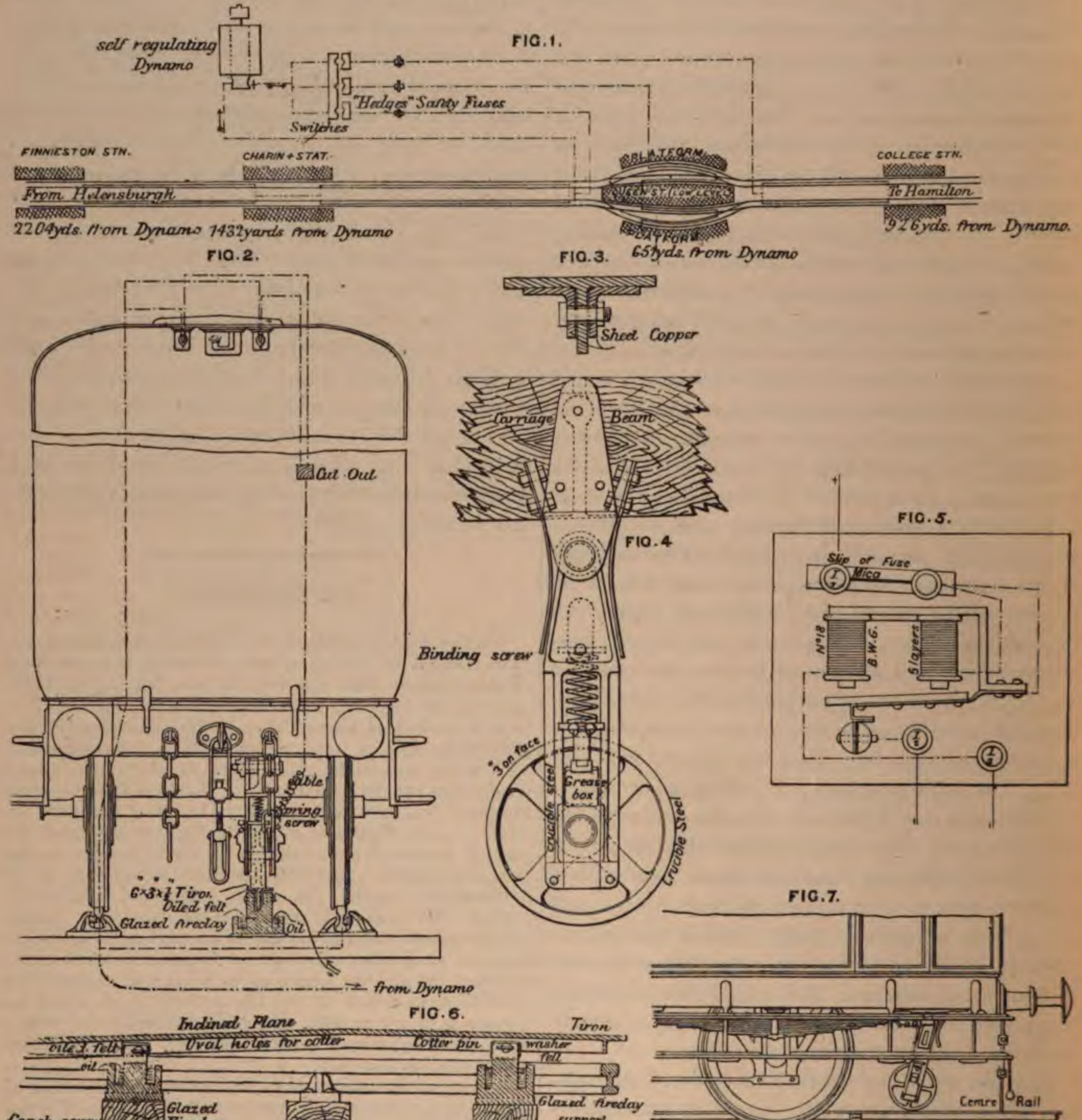
ourselves justified in commencing this series of portraits of eminent electricians of this century with that of Dr. Wollaston, which is given with our issue of to-day.

ELECTRIC LIGHTING OF TRAINS.*

There are three methods of train lighting in use, namely, by oil, gas, and electricity. As this paper is only intended to deal with the latter the first two systems will be passed over. The amount of light from each is in favour of gas against oil, and of electricity against gas. Incandescent lamps only are used in train lighting by electricity, the arc light not being suitable. In using the incandescent lamps they are placed in each compartment, and generally take the place of the oil or roof lamp. There have been three practical applications of train lighting by electricity. In the first two the roof lamps are replaced by incandescent lamps, while in the third case they have not been interfered with. The first two methods are those which have been more or less used, while the third has just been tried.

*Abstract of Paper read before the Philosophical Society of Glasgow, by *Thos. P.* Carswell.

What I propose to speak of as the third method (patented May 17, 1886), is that which is now being tried for the first time, I believe, on the Glasgow City and District Railway. On the City and District Railway the circumstances under which the light is required are entirely different from almost all others, as it is specially required during the day and while the trains are in the tunnels only. These trains run in the open air the greater part of their journey, but have to pass through the tunnels from three to fifteen times daily; or, in other words, they are on an average somewhat over an hour in darkness. The arrangement for lighting each train as it enters the tunnel is as follows:—



A centre or third rail has been laid down from one end of the tunnel to the other, but is omitted in the open air, Fig. 2. It is formed of ordinary T iron, and is inverted and laid on insulators or supports, so that it stands 4in. or 5in. higher than the ordinary rail, as shown in Figs. 2 and 7. It is jointed together by small angle irons with four bolts, there being a small strip of sheet copper between the two, so as to help the contact, Fig. 3. The holes in the rail are oval, to admit of expansion and contraction, and it is held in position by iron cotter pins, which pass through the sides of the jaws or supports. At each end of the tunnel

this centre rail or inverted T iron is bent down to the level of the ordinary rails so as to form an inclined plane (Fig. 6).

The insulators or supports which are used are made of glazed fireclay, and have the central part or stem isolated from the base. The stem has two slots in it, one to receive the T iron and the other for the cotter or split pin to pass through. A small piece of roofing felt, soaked in oil, is laid in the slot on which the T iron rests. The lower part or base is made in the form of a trough, which is filled with oil to help the insulation, and is fastened to the sleepers by means of two coach screws.

By this method of fixing the centre rail it is always kept at the same height above the ordinary rails, and if the latter are raised the former is raised also as it rises with the sleeper. These supports are fixed about 5 feet apart, and as far as can be seen they stand very well.

Two contract makers or pulleys (Figs. 2, 3, and 7) are fixed to the framing of each carriage, at a height to correspond with that of the centre rail. Only one is actually required, but it is found that two give a steadier light, and where there are junctions to pass over both are required to maintain the connection. These pulleys are made of crucible cast steel and are 15in. in diameter. They are hung on a centre so as to move in a horizontal direction, and have a spiral spring on the top of the axle-box, which allows it to rise vertically 3in. or 4in. Two side flat springs are fixed on the hanger or jaw in which the pulley works so as to keep it in a vertical position.

The current of electricity for lighting the lamps is derived from a large Crompton compound-wound self-regulating dynamo, having a potential at the terminals of 110 volts. This dynamo is always kept running, the positive lead being connected to the centre rail, and the negative lead to the ordinary rails. It is driven by the same engine as is used for lighting Queen-street high level station. The leads are not connected directly with the centre rail, but to three Hedges' safety fuzes in the engine room, designed to give way in case of a short circuit (Figs. 1 and 5).

The tunnel is divided into three circuits, namely, College to Queen-street Station (low level), and Queen-street to Charing Cross, and to Finnieston, as shown in the last-mentioned figure. By this means, in the event of there being a breakdown in either tunnel, it can be switched off so as not to interfere with the other two. The lengths of the circuits are 748, 484, and 2,196 lineal yards respectively. The area of the centre rail increases as it leaves the dynamo, while the resistance to each circuit is the same. The estimated loss or fall in potential at the end of each circuit, with a train in it, was 10 volts, and it is found that at Finnieston Station, which is 2,196 yards away, such is the case. It is possible to have two trains in two of the circuits and four in the other, or eight in all; and the cables leading to each have been arranged accordingly. Insulated cables, laid in creosoted troughing and filled with pitch, have been laid from the dynamo to the centre and ordinary rails.

The wires from the contact pulleys are connected to two 16 candle-power lamps, which have been placed in each compartment, fixed on either side of the ordinary roof lamp, so as not to interfere with it, and in order that the latter can be used when required (Fig. 2). These lamps, which are of the Swan type, are 25, 34, 50, and 100 volt lamps, also Brush 50 and 100 volt lamps, all of 16 candle-power nominal, but only one is lit at a time, the second being a reserve which automatically lights itself in the event of the first one failing.

Each circuit is formed in the following way: The positive lead to the lamps is connected to the two contact pulleys, while the negative is connected to the spring of the carriage. It will thus be seen that as soon as the train enters the tunnel the pulleys make contact with the centre rail, the current flowing from the dynamo through the centre rail and pulleys to the lamps, and returning through the springs and wheels of the carriage to the ordinary rail, and through it back to the dynamo again. On the train leaving the tunnel the pulleys run down the inclined plane of the centre rail, breaking the connection and so putting the lamps out.

As regards the power required for each train, it may be said to be about 2,000 watts, or from two to three horse-power.

In order to prevent the rusting of the centre rail, and to keep it clean so as to make good contact, a steel wire brush is fixed on one carriage in each train. It is found that the brush makes better contact and gives a steadier light than the pulley, but, owing to the friction, the tear and wear would be too great to adopt it entirely.

It is found that the small "cut-outs" work best either with the 25 or 50 volt lamps, as they take more current, but even regulated and connected to a single 100 volt lamp they act well.

As already mentioned, the end of the centre rail at Finnieston station, which is furthest away from the dynamo, is distant about 1¼ miles (2,196 yards); and at this point, with one train in circuit or 36 lamps, the potential is 100 volts, or that required to light the lamps.

The insulation of the centre rail is not quite perfect, there being a slight leakage, but it cannot be traced to any particular part, and it is practically inappreciable, being only about 3 amperes. This leakage may arise by the steam conveying the current to "earth," as on a dull day the centre rail is quite wet; and in the distance from the dynamo to Finnieston the area exposed is no less than 840 square yards on one line alone, so that the leakage is not to be wondered at.

It will be seen that by this system the train, or rather each carriage, is lighted and extinguished on entering or leaving the tunnel—automatically, as it were. There are no connections between the carriages, so that the train can be broken up or shunted as usual, while the light is maintained whether the train is in motion or at a stand.

During the New Year holidays some of the trains were running with only one carriage fitted, while others had six or eight fitted and the remainder not.

During the passage of these trains through the tunnel the speed of the dynamo was nearly constant, and their presence in the circuit could only be detected by a slight hissing noise at the commutator brushes and a faint sparking, if any. This system has now been in use four months, and two trains have been running all this time, only being off one day weekly to be cleaned. The number of lamps in the two trains was, on an average, 60; and in the four months' lighing three of them have had to be renewed. Two of the three were broken maliciously, the outside globes having been broken also, while in the other the carbon filament gave way, having burned 100 hours.

Since this paper was read, twelve trains—or, in all, 89 carriages—have been fitted, and are running daily. Taking the running of the trains for six months the total number of lamp hours is 39,642. During this time it has been necessary to replace 44 lamps, so that the average life of the lamps has been 900 hours each, but as 11 of these lamps were broken maliciously by passengers in the trains, their actual life is 1,210 hours.

In this system the electric light is not used at night, the gas or oil lamps being still made use of, which are there to fall back on should a breakdown take place. In the other systems the electric light was used alone, and could be made use of any time, whereas in this it can only be had in the tunnels. Of course, it has the advantage of allowing the trains to be broken up (which is done sometimes twice a day) without having any extra couplings, and having the light only when required, without the control of any one. The cost of this system is less by a fourth than that of either of the other two, and fully a third less than that of gas, while the working expenses are much the same as the first two systems, but a third less than gas lighting.

Journal of the Society.—Part 69, Vol. XVI., of the Journal of the Society of Telegraph Engineers has just been issued. This part contains the discussion on Prof. Fleming's and on Prof. Ayrton's papers on measuring instruments; the report of the council to the sixteenth annual general meeting; and the paper by Mr. A. C. Cockburn "On Safety Fuses."

CORRESPONDENCE.

PARIS EXHIBITION, 1889.

To the Editor of the Electrical Engineer.

Sir: I am instructed by the President and Council of the Society of Telegraph Engineers and Electricians to request the favour of your giving as early an insertion as possible to the following notice:—

"International Exhibition, Paris, 1889.

"In view of the interests of English electrical exhibitors, the Society of Telegraph Engineers and Electricians have appointed a committee to endeavour to ascertain their wishes and to make arrangements on their account with the French authorities. The Director-General of the International Exhibition having requested the society to take part in the matter on behalf of the official administration, it is proposed shortly to address a circular to the principal firms interested in electric lighting and kindred pursuits, and to convene a meeting of gentlemen who are likely to take part as exhibitors in the forthcoming display.

"It is of extreme importance to British industries that they should be well represented on the occasion referred to, as without it there is danger of Continental opinion assuming that England has fallen back in the race for success in the alliance between Science and Commerce.—Yours, &c., "F. H. Webb, Secretary.

"Society of Telegraph Engineers and Electricians,

"London, 1st February, 1888."

ELECTRIC LIGHTING.

[The following letter appeared in *The Times* of Tuesday, and a copy has been forwarded to us. It seems desirable that both those connected with the industry, as well as the public, should be kept cognisant with whatever is done in connection with Parliamentary action as regards electric lighting.—Ed. *E. E.*]:—

To the Editor of the Times.

Sir: All who are connected with the electric lighting industry are looking forward with anxiety, yet with hope, to the forthcoming meeting of Parliament. I, therefore, crave permission to say a few words in your columns in support of the right of the public to have electric light, and of our claim to be relieved from the hindrances which Parliament, legislating at a time of unfortunate electrical speculation and excitement, thought fit to place in the way of the development of public central electrical lighting. The report of the House of Commons Committee on lighting by electricity, 1879, said, "Your Committee would observe generally that in a system which is developing with remarkable rapidity it would be lamentable if there were any legislative restrictions calculated to interfere with that development." The lamentable result of the legislative restrictions of the Electric Lighting Act, 1883, is that, while thousands of people are anxious to have electric light in their houses, there is not a single central station in the United Kingdom lighting the whole of any given area, its streets, public buildings, offices, and private houses, such as are common from New York to San Francisco, and are to be found at Berlin, Vienna, Dijon, Milan, Melbourne, and other places. Every first-class steamer that is built is now supplied with electric light, clubs, banks, hotels, go to the expense and suffer the annoyance of having an installation on their premises, a few of the wealthy treat themselves to the luxury, but the hundreds of thousands of moderate means and the great majority of the well-to-do are not able to avail themselves of the beneficial discoveries of Edison and Swan, of Siemens and of Brush and others, but are fast losing hope of ever having electric light brought to their houses as readily and as cheaply as the dangerous and noxious, but useful and familiar gas.

The recent Parliamentary phases of the question are as follows:—

In 1886 Lord Rayleigh brought in a Bill in the House of Lords, which may be summed up by saying that it proposed that the electric light companies should be put upon exactly the same footing, alike as to restrictions and privileges as gas companies.

This Bill commended itself by its fairness, to a great number of impartial men, and as it was based on the opinion of a Committee of the House of Commons we had good hope of its passing. It would have been accepted by the electric companies and firms, many of whom would have to set to work under its provisions, and I have no doubt that if it had passed we should have had by this time a score of central stations in many towns distributing the electric light to willing customers.

In 1887 Lord Thurlow brought in a Bill. Lord Thurlow, from his connection with the industry, and from his position as chairman of the Electric Light Committee which assisted Lord Rayleigh in preparing his Bill, is familiar with the requirements of the public and the conditions on which electric lighting can be made to pay, and his Bill held the balance fairly between the trade and the public. Supported by the Prime Minister, Lord Cranborne, Lord Herschell, Lord Bramwell, and others, this Bill passed the House of Lords, but, alas! did not pass into law. The Marquis of Salisbury, in his speech in the House of Lords on this Bill, as reported in *The Times*, summed up the position so moderately and fairly that I hope you will allow me to quote an extract therefrom:—

"He did not dispute that this was a very suitable matter for local authorities to undertake if they were willing to do so, and he could quite imagine that in 1882 the Board of Trade and the local authorities, generally speaking, thought it would be a pity to allow companies to step into their place. But five years were passed away and they saw that the local authorities were not generally inclined to take this enterprise up. They were really putting the local authorities in the position of the dog in the manger —they would not allow companies to enter upon an enterprise which they would not undertake themselves. He was inclined, in spite of the terror of the example of the gas and water companies, to go back to ideas of less restriction and of greater freedom in the matter, to allow enterprise to have its full swing, to remove all obstacles which had hitherto impeded it, and to offer terms not such as they thought the capitalist ought to accept, but which they felt by experience he would accept. So it might be possible, by giving rights which were generous and large, to procure for the public the full advantage of those scientific inventions which other nations had, and which now, by a restrictive policy, we prevented ourselves enjoying, without doing any good to those local authorities which were the subject of such tender care."

As the Prime Minister said, five years have passed and not a single local authority has established an electric lighting station; surely it is time to relieve us from conditions which prevent the public from having the light, and injure and cripple our business. It is a new thing in England that we should be prevented by legislation from availing ourselves of the discoveries of science, though they are acknowledged to be useful and beneficial, and though hundreds of thousands of people are anxious to make use of them.

Mr. E. Graves, engineer-in-chief of the Post Office and president of the Society of Telegraph Engineers and Electricians, in his presidential address, which was reported in *The Times* of the 13th inst., said that 42,368 persons were employed in the United Kingdom in connection with telegraphs, telephones, cable-making, and allied businesses, of which number 5,000 were employed in connection with electric lighting, and he placed the probable number employed in connection with the above industries throughout the world at about 310,000. If an Electric Lighting Act rendering central stations possible is passed in 1888, it will give immense impetus to the electrical trade, and I am certain that I do not exaggerate the advantage which the working classes would gain when I say that within a couple of years of the passing of such an Act, some 100,000 men, women, and children would find healthy and profitable employment. This would be of great advantage in these days of depressed trade, and it is as unwise as it is unfair to persist in maintaining legislative restrictions which have punished the companies and the public without conferring any benefit upon the local authorities.

In America arc lighting is used for street lighting in

almost every town, and incandescent lighting is now quite general. I have been speaking this afternoon to Mr. Edison's European representative, and I gather that the increase of incandescent lighting has been about 40 per cent in 1887 over its use in 1886. There are no less than 121 local Edison companies in the United States, the dividends in which vary from 6 to 14 per cent., and an American gentleman told me recently that he had shares in four electric companies, and had received dividends from the four averaging 11 per cent. on his investment.

I think, Sir, that however weak my pen may be, you will allow that I have made out a fair case for the intervention of Parliament. If you will give your powerful support to our oppressed industry, if Lord Thurlow will re-introduce his Bill, or better still if the Government would legislate on the subject, we may fairly hope that before long central stations for the distribution of the electric current may be established in many towns, giving work to thousands of mechanics, affording a safe investment to capitalists who would be content with the moderate dividends which would certainly be earned in supplying the public with electric light.

I am, Sir, your obedient servant,

S. Flood Page, Secretary and Manager.

Edison and Swan United Electric Light Company (Limited), 13, Albert-mansions, S.W., Jan. 25.

ON THE POSITION AND PROSPECTS OF ELECTRICITY AS APPLIED TO ENGINEERING.*

BY MR. WILLIAM GEIPEL, OF EDINBURGH.

In the present paper the author purposes confining his remarks to those branches of electric engineering which involve the employment of considerable power and are in some way connected with the use of dynamo machines. The principal of these may be treated under the four following heads :—

I. Electric transmission and distribution of power.
II. Electric locomotion.
III. Electric lighting.
IV. Electric metallurgy.

I. Electric Transmission and Distribution of Power.

In the near future this branch of electric engineering will probably occupy more attention and call forth more outlay of capital than either of the three others mentioned above; already, indeed, it is commanding a great deal of attention. Owing to its simplicity, the ease with which an electric motor can be applied to any purpose requiring power, and its high efficiency, it is certainly an approach to an ideally perfect system of transmission. No greater contrast can be imagined than the difference between the position of electricity in this country and in America. On the other side of the Atlantic, although the science of electricity is much behind, the practice is far ahead of our own. European science has supplied an agent, the value of which has been recognised by American engineers; and now in the United States the applications of electric motors are already rivalling and will soon excel in importance the application of electricity for lighting purposes. It is to be remembered, however, that there, owing to the high price of coal, the use of steam-power is a more serious consideration than here; they have also in many places abundance of water-power which can be utilised by electric transmission. Notwithstanding these differences, there is in our own country an almost unlimited field for the employment of this mode of transmitting power cheaply to a distance, and of distributing power generated at a central station to a number of users in the neighbourhood.

Were it not for the cost of the dynamos and motors, electricity would supersede to a great extent the use of belts and shafting. In large works, where high speeds are required and the demand for power is variable, the efficiency of belts and shafting is very low indeed. As much as 25 per cent. of the power may be absorbed by the shafting when the full number of machines are in use; and in such a case with half the machines in use the loss of power rises to nearly 50 per cent., while in the extreme of driving only a single machine even 99 per cent may be lost. With electricity, on the other hand, no power is being used in keeping the transmitting medium in motion, the conductor being stationary; the loss takes place only whilst power is actually being used by the motors, each of which drives its own machine. In fact the percentage of power lost in the transmitting medium becomes smaller as the amount of power transmitted is reduced, which is exactly the converse of what happens with belting and shafting. For the sake of illustration and comparison, let it be assumed that a loss of 25 per cent. of power would take place in the electric conductor when the full load is on: although in reality the loss would never be above 10 per cent., and need not be more than 5 per cent. Then with half-load the loss would be $12\frac{1}{2}$ per cent., and so on; and with one machine possibly one-tenth of 1 per cent. might represent the loss in the conductor. When it is remembered in how many cases the average load in a factory is less than half the maximum, it is evident that this point is one demanding the greatest consideration. In New York, where a large number of motors are supplied with current from the electric-light mains, it has been found by experience that on an average less than one-third of the whole number of motors are in use at any one time.

The depreciation of the electric conductors is comparatively small; but whether the saving of renewing belts and of lubricating shafting would not be counterbalanced by the wear and tear of motors, is a question to be settled by individual experience. The advantage, however, of getting rid of shafting, thereby obviating the necessity of additional stability in the building and doing away with constant lubrication, and the further advantages of saving the space and light absorbed by belts, and of the ease with which the conductor can be shifted to suit any desired alterations in position of machines, are also very important matters.

The distribution of power by electricity from a central station to small users will, in the author's opinion, form in many towns a larger business than the lighting. Both can be done from the same mains and generators, just as is the case with gas; it is merely a question of economy and convenience as to whether gas or electricity should be used. The encouragement of small industries has long demanded some cheap means of obtaining power in small quantities —say, from $\frac{1}{2}$ to 25 h.-p. The gas engine has not altogether met the requirements of small establishments, although needing but little attendance; for the first cost of even a small engine is high, and the amount of gas consumed is large. Moreover the speed is generally irregular, owing to the intermittent impulse, which is more especially noticeable with light loads; and a considerable amount of wear and tear takes place in the valves and working parts.

An electric motor can be started and stopped at will with the greatest ease; it requires the smallest amount of attention, occupies the minimum of space, and can be placed in almost any position. An ordinary shunt-wound motor will run at an almost constant speed, with a maximum variation of only 5 per cent. from running light to fully loaded; this fact was first pointed out in an interesting paper in the *Philosophical Magazine*, for January, 1886, by Mr. Mordey, who has done much valuable work in the perfecting of the modern dynamo machine. He has kindly sent the diagram exhibited, showing the result of some tests of a Victoria motor for change of speed under variable load, which illustrates the remarkable constancy of speed attained. This exceedingly close regulation was obtained by using a simple shunt motor of suitable construction, and without any accessories such as the many forms of governing devices to which so much attention had previously been devoted. The result shows that such a motor possesses a practically perfect power of self-control, not only over its rate of speed with varying load, but, what is of equal importance, over the energy absorbed by it; for it helps itself, as it were, to only such an amount of energy as will enable it to deal with the work imposed on it. Another advantage in the use of shunt motors is that they act as generators when themselves driven by any extraneous power, without any complication of switch gear such as is required with a series

* A paper read before the Institution of Mechanical Engineers, February 2, 1888.

motor. This fact was first pointed out by Sir William Siemens in a paper read before the Society of Telegraph Engineers, 3rd June, 1880. In such a system, where railways, lifts, &c., are being worked by motors, the current generated by descending trains or loads might suffice at times might suffice at times to supply the rest of the motors with sufficient current for their work, without absorbing any current from the dynamo; at any rate it would reduce the amount of current required to be supplied by the dynamo. The first cost is also small compared with that of a gas engine. A 1 h.-p. motor will cost £20 against £100 for a gas engine. The cost of running a gas engine is about one penny per horse-power per hour for gas alone; the same power generated by a dynamo driven by an efficient steam engine costs only about one farthing, current being supplied from street mains just as gas is.

As small steam engines are being superseded by gas engines wherever the outlay for the latter can be afforded, the competition in regard to small powers lies between gas and electricity, and steam may be left out of the question. There is of course a limit above which steam becomes the cheapest; and probably 10 h.-p. may be taken as about that limit in this country. In Boston, in the United States, where some hundreds of motors are supplied with electricity from central stations, they range from ½ to 15 h.-p., and are working lifts, printing establishments, small machine shops, and watch-making, tailoring, boot-making, and similar industries. Their working seems to be highly appreciated; and the author understands the users would be willing to pay even 25 per cent. more for them, in consequence of their convenience and regularity in working. In Geneva, within a radius of a mile and a quarter, there are no fewer than 175 motors at work, varying from ½ to 70 h.-p., supplying power to small workshops and for other purposes, the electric power being obtained from dynamos and turbines which are driven by water power derived from the Rhone. The installation is paying its way, and is about to be largely increased. At the Falls of Niagara plant is being put down to distribute power obtained from the falls to neighbouring towns, including Buffalo which is 20 miles distant; the amount of power is stated at 15,000 h.-p.., of which 10,000 h.-p. is contracted for at £3 per horse-power per annum for power and lighting purposes in Buffalo.

As an interesting example may be mentioned a 6 h.-p. motor recently erected by the Brush Company of Cleveland, Ohio, in a printing establishment, where it was connected with the regular arc-light circuit. It takes the place of a 10 h.-p. steam engine, which had sometimes come to a standstill under its load. It drives about 70 to 80 feet of shafting, three cylinder presses, four platen presses, one large paper-cutter, and one very heavy lift; and by a 4in. belt carried up through three floors it also drives three ruling machines and four paper cutters. It does its work splendidly, and its motion is steady and regular. It has proved to the proprietor's satisfaction that printing offices could well afford to employ electricity instead of steam, even in cases where the first cost might be more. In many other towns in America, where the electric light mains are within reach, the number of motors already in use is very great; within two years 5,000 motors have been supplied by one firm alone, and the author understands that the Brush Company are turning out as many motors as dynamos.

In some places in this country, and more especially in Lancashire, it is customary for power to be supplied from a large steam engine to neighbouring buildings, which are let out as separate workshops. In such instances, however, the power supplied is more frequently above than below 10 h.-p., and probably it would not pay to introduce an electric motor. Still it should not be forgotten that in renting these workshops considerable inconvenience may be incurred as regards the locality of the premises for the manufacture; moreover, the rent is often disproportionately high.

Many schemes have been propounded for distributing power in manufacturing districts by means of steam, compressed air, and water pressure, each of which is in use to a somewhat limited extent; and as all of them have been known long enough, it may seemingly be inferred from their limited employment that there is not much to recommend their extended use commercially. With steam, the condensation in the pipes causes loss of pressure, and results in wet steam being supplied to the engines. Compressed air cannot efficiently be worked expansively, and is attended with loss of heat in the compressor. Water pressure commonly involves using the maximum power, whatever the work required. Besides these prominent faults of the three several methods, what is of the greatest importance and common to all three is that the generating plant has to be used almost exclusively for supplying the power, and cannot be utilised for other purposes in addition; whereas with a central electric station the engines and dynamos serve to generate current for lighting purposes also at night.

Collieries.—In collieries electricity will be largely adopted in the near future. For underground hauling, pumping, ventilating, and drilling, it can readily be applied with an efficiency double that of compressed air. With a well-arranged installation, 75 per cent. of the brake power of the engine will be utilised on the shaft of the motor.

For hauling and pumping, wire ropes or rods are the greatest competitors of electricity, which obviates the following disadvantages in connection with them:—Chance of breakdown through strain; wear and tear; mishap to guides through falls of roof or dirt; trouble and expense of oiling the guides; and room required at pit mouth or at bottom for engine, pulleys, or levers, or other gear. As the tendency in mines in this country is towards a reduction of working hours, the question of mechanical haulage becomes most important, because horses must be fed whether at work or idle, and the cost of haulage by horses therefore increases as the working hours become reduced.

For ventilating and drilling, compressed air is, perhaps, most largely used; and one of the great points in its favour is that the exhaust is available for supplying fresh air to the miners, and for driving out the foul gas after the firing of shots. But the cost of the compressed air machinery is heavy, as is also that of the pipes for conducting the compressed air from the compressor to the place where it is used. The cost of electric plant is somewhat less, and the efficiency is very much greater; while by using old haulage ropes as conductors the cost of this item is rendered very small.

At Trafalgar collieries, in the Forest of Dean, there is an interesting instance of pumping on a small scale. A Gramme machine driven at bank supplies current to a motor in the mine 800 yards distant from it. A current of 15 amperes at 100 volts, equal to 1,500 watts or 2 h.-p, is found sufficient to work the pump, which is double-acting, 5in. diameter and 8in. stroke, and runs up to 70 revolutions, or 35 gallons per minute, lifting about 90ft. The entire installation cost £250; it has been working about four years, and has given so much satisfaction that additional plant has lately been put in at a distance of 1,650 yards from the pit shaft for lifting 120 gallons per minute 300ft. high, the distance between the pump and the generator being 2,200 yards. A double-throw pump with 9in. plunger and 10in. stroke is driven at 25 revolutions per minute by spur gearing reducing 6 to 1, the small pinion being driven by a belt from the motor. Current is conveyed to the motor by a conductor composed of 19 wires No. 16 S.W.G. (0·065in.) thick, giving 0·065 square-inch total sectional area, insulated and carried on earthenware insulators; an old 4in. wire-rope serves for the return circuit. The efficiency obtained throughout is only 35 per cent.; but as much as 6·49 h.-p., or 22 per cent., is lost in the engine alone, which is an old one. The cost of engine and electric plant and pump complete was £774, without pipes. The weekly cost of maintenance is given as follows by Mr. Brain, the colliery manager:—

Engineers, half time	£1	8	0
Men underground, full time	2	9	0
Small coal consumed, say 36 tons at 1s......	1	16	0
Oil, waste, and sundries	0	7	0
Interest and depreciation, say 15 per cent....	1	17	0
Total per week	£7	17	0

Total per annum £408, showing a yearly saving of £470 on the water-power that was superseded. The cost of the water raised is 0·02 penny per h.-p. per hour, and 1·8 pence

per 1,000 gallons. At the same collieries a 6-ft. fan is also being worked by an electromotor at 1,800 yards distance from the generator.

(To be continued.)

ELECTRICAL MEASUREMENTS, ESPECIALLY AS APPLIED TO COMMERCIAL WORK.*

BY PROF. WM. A. ANTHONY.

(Continued from page 93.)

We need, however, instruments for measuring currents in the workshop and about dynamo machines, and a great variety of instruments called ammeters have been constructed for these purposes. In general, such instruments consist of a coil of wire developing a magnetic field which is compared with an artificial field produced for the purpose, or the magnetic force developed by the coil in the presence of some other magnetic field is balanced by some known force. To be more explicit, one form of ammeter consists of a coil which tends to deflect a needle against the artificial field of a permanent magnet. The accuracy of these instruments depends upon the constancy of this opposing field. But no permanent magnet does remain constant, and these instruments, therefore, need to be frequently calibrated. Another form of ammeter is one in which the coil acts upon a mass of soft iron, developing a force which is opposed by a spiral spring. Here the accuracy of the instrument depends upon the constancy of the spring and upon the constancy of the effect of the little mass of iron.

And here let me say that a magnetic field is not of itself a force. To have *force* there must be two magnetic bodies, and the force exerted depends as much upon the one as upon the other. A coil of wire conveying a current develops a magnetic field, but before a force can be produced something else that can also develop a magnetic field, as a mass of iron, a magnet, or another coil of wire carrying a current, must be brought within the range of its action. If this second body can only produce a weak field, then only a feeble force will be produced. Moreover, the force will vary with every change in this second body, even if the current in the primary coil remain constant.

Speaking of this fact, of the necessity of two magnetic bodies to develop a magnetic force, reminds me of a question often asked in regard to extracting particles of steel that have become imbedded in the eye. Would not a sufficiently powerful magnet draw it out? I always tells the questioner that the most powerful magnet in the world could exert but a small force upon a little particle of steel. If you can loosen the piece of steel, a magnet is a very good means of taking it out of the eye, but then a small magnet does as well as a large one. I was once told by a gentleman that he had known of a sewing needle that was deep down in the flesh of the leg being drawn out by the application of a powerful magnet. I remembered how little force the most powerful magnet can exert where a sewing needle is the body attracted, and thought to myself that the statement needed confirmation. Some of you will remember that when it was proposed to build the 1,000 feet iron tower in Paris, it was predicted that all the loose iron articles, knives, joiners' tools, chains, tin pans, to say nothing of wagon-tires and horseshoes, would come rushing pell-mell to the base, in consequence of the tower becoming a great magnet by the earth's induction. Yet, notwithstanding the prediction, I do not think I should take the precaution to leave my keys and pocket-knife this side the water if I were going to visit Paris after the erection of the great tower.

But to return to our ammeter, the little mass of iron is attracted by the coil, because it becomes itself a magnet. If it become a strong magnet, it is attracted strongly; if it become a weak magnet, it is attracted feebly. Its magnetic strength will not be the same under all circumstances, and the force exerted by the coil upon it is, therefore, not always the same when the same current is flowing. I have recently re-calibrated an Ayrton and Perry instrument of the permanent magnet type, and found its constant had changed 16 per cent. since last March. Last spring I calibrated two spring ammeters at the same time, and found one to read 5 per cent. fast, while the other was nearly as much slow.

Do not understand from this that I consider these instruments of little value. They are the best we have. What I want to impress upon you is the importance of frequent comparison of the instruments with others known to be standards. Theoretically, the best ammeter is one in which the force exerted between two coils in the same circuit is opposed by gravity. Here the force developed depends only upon the current which it is desired to measure, and the opposing force is the one force at our command that does not have to be watched and tested, but is the same to-day as yesterday, and can be trusted to be the same to-morrow as to-day. Such an instrument would, therefore, give uniform indications. (Thomson instruments exhibited.) There are, however, practical difficulties in the way of constructing such an instrument for the measurement of large currents. One of the coils must be movable, and it is difficult to take a large current to and from it without imposing some constraint upon its motion. We still want for commercial use a really good ammeter for measuring large currents, one that we can trust as we trust our scales for weighing merchandise, to give correct indications for weeks and months and years.

I have dwelt thus upon these instsuments, which measure rate of flow, because, as I have already said, some of the most important effects of electric currents depend upon this element. There are cases, however, where we wish to know the total quantity of electricity flowing in a given interval, and care nothing for the rate of flow at any given instant during that interval. For instance, we are furnishing a house with incandescent lights. It is important to know the quantity of electricity furnished per month. The unit in which we measure electricity in such cases is the quantity conveyed in one second by a current of one ampere. This is the coulomb already spoken of. It has not been found easy to construct a reliable coulomb-meter. The Edison Company use a meter in which the current deposits zinc upon a zinc plate. This is a very good method for the laboratory, but it is difficult in practice to fulfil all the requirements for completely reliable meters. At least, so far as I can learn, neither the consumers nor the company seem to be perfectly satisfied. The new coulomb-meter exhibited and described by Prof. Forbes about a month ago, at a meeting of the Electrical Engineers in New York (and in this Hall), depends for its action upon the development of heat in a wire by the flow of the current. The wire, in the form of a flat spiral, is placed below a little windmill. The flow of electricity in the wire heats it, and so sets up air currents that cause the little windmill to revolve. A train of wheel-work, connected with the windmill, actuates the hands in front of a dial. Thus the instrument registers the flow of electricity as a gas meter registers the flow of gas. Practical experience only can tell whether this instrument will fulfil all the requirements.

But the measurement of currents or of quantities of electricity is but a small part of what is required in electrical measurements. Potential in many cases is quite as important an element as strength of current or quantity. To go back to our analogy of a flowing fluid, we know that pressure is necessary to bring our gas to the burners, but so long as it is sufficient to supply gas in proper quantity and gives us a good light, we do not trouble ourselves about it. It is the business of the gas company to maintain the required pressure, and they must adjust by a pressure gauge. It is the chemical energy of the gas that gives the light, and the energy due to the pressure is too small an item to be considered. But suppose we are supplying steam or compressed air for driving engines, the pressure is now a more important item. The power used is the product of pressure by volume of steam used per second. Pressure is, therefore, one of the items that the consumer pays for. Where electricity is supplied for any purpose, the energy which the consumer pays for is the product of potential by quantity. Varying either factor varies the energy delivered; and measurement of potential is, therefore, as important as measuring quantity or current. The unit in which we measure potential is based upon the relation just stated, that the product of potential by quantity gives the electric energy. The absolute unit potential is the potential under which the absolute unit current performs the absolute unit work in unit time. A true volt is 100,000,000 absolute units.

Before taking up the methods of measuring potential, let us consider the other electrical units and their relations to those already defined. The farad, the unit of capacity, is the capacity of a body which contains one coulomb when charged to a potential of one volt. At a potential of two volts the same body would contain two coulombs, but its capacity is still one farad. It is as though we were to define a gallon as the capacity of a vessel which holds one pound of air under a pressure of one atmosphere. Under two atmospheres the same vessel would hold two pounds, under half an atmosphere half a pound.

The ohm is the resistance of a conductor in which the volt maintains the current of one ampere. These are the true definitions of these units, and need to be carefully considered when our measurements involve the determination of electric energy. To see how this is important, let us consider the actual measurement of a resistance. To measure a resistance upon the basis of the definition just given is a very difficult operation. So difficult that even after twenty-five years of such measurements we do not feel very certain of the value of the ohm. In 1862 the British Association appointed a committee to determine the ohm and construct standards. After some years of labour standards were produced, consisting of coils of wire supposed to have the resistance defined as the ohm. From these resistances boxes are constructed and resistances are measured by comparing the unknown with these known resistances. This is a very simple matter, and can be quickly and accurately done. The difficulty of measuring a resistance upon the basis of the definition of the ohm is shown by the fact that later determinations indicate that the British Association standard, now known as the B. A. ohm, is about one and three-eighth per cent. too small. The Paris Congress, recognising the difficulty of arriving at a positive value on account of the dis-

* Abstract of a lecture delivered at the Franklin Institute.

crepancies between the results of different observers, adopted a standard, the resistance of 106 centimetres of mercury one millimetre in cross-section, to be called the *legal ohm*. This, according to the best of our present knowledge, is about one-quarter of one per cent. too small. They further decided that the unit current should retain the value assigned by the British Association, and adopted as the *legal volt* the potential difference that maintains a current of one ampere in the legal ohm. The legal volt is, therefore, about one quarter of one per cent. too small.

Now, suppose we have measured a current in amperes and the potential in legal volts ; multiplying, we obtain the energy, but, since the unit in which potential is measured is too small, the result is too large, and must be reduced one-quarter of one per cent. to obtain the true energy. I think it unfortunate that the legal standard was not made 106·25 centimetres of mercury, for it seems certain that this amount, to the fourth figure at least, is the correct value of the ohm. If the legal ohm had been so chosen, computations of energy based on measurements in legal units would not have been in error by more than one-tenth of one per cent., and for all ordinary purposes corrections would have been unnecessary. The measurement of a potential in legal volts is not a difficult matter. It consists in measuring the current maintained in a conductor whose resistance is known in legal ohms. A standard instrument for such a purpose would be a delicate galvanometer whose coils consisted of many turns of wire of a known high resistance—of high resistance, because the instrument must take so little current from one point to the other as not appreciably to alter the difference of potential between them. (Experimental illustrations.) A multitude of voltmeters for commercial measurements are on the market, most of them being instruments similar to the ammeters already spoken of, but with coils of very fine wire in which a current, proportional to the difference of potential, is produced. In fact, the ammeters and voltmeters often look so much alike that they could not be distinguished, except for the words "volts" and "amperes" on the dial. These instruments are as likely to change as the corresponding ammeters, and require the same precautions as regards calibration.

But there are other ways of measuring potential that do not depend on the measurement of a current. If two plates are connected, one to one point and the other to another, the difference of potential between which is wanted, these two plates, when brought near together, attract each other with a force proportional to the potential difference. This force of attraction is, however, very small, and requires an extremely delicate instrument to indicate it, until the potential difference is 400 or 500 volts. (Thomson's voltmeter shown.) Another method of measuring potential is to balance the unknown against a known potential. The difficulty in applying this in practice is to obtain a reliable standard. Voltaic cells afford the best means of obtaining a fairly constant potential difference, but only under very exact conditions are these potentials sufficiently uniform to be accepted as standards. (Potentials of cells measured.) A gravity cell that had been in use some time gave a deflection of 46. One set up about eight hours before the lecture gave 64, and one set up just at the beginning of the lecture gave 65.

(To be continued).

ON SOME INSTRUMENTS FOR THE MEASUREMENT OF ELECTROMOTIVE FORCE AND ELECTRICAL POWER.*

BY J. A. FLEMING, M.A., D.SC. (MEMBER), AND C. H. GIMINGHAM.

(Concluded from page 92.)

[Fig. 6 shows collar referred to in paragraph 3, p. 91, and Fig. 7 shows needle carried by movable coils, *see* paragraph 2, p. 92.]

We have also constructed, on this type, a Wattmeter. In this case the fixed coils (now called the current coils) are wound with thick wire, and so arranged that the four coils can be joined up in series or in parallel. From a separate pair of terminals the current is conducted into the thin wire coils, which are the movable coils, and constructed exactly as for the voltmeter, only with a higher resistance. (See Fig. 8.) In using this Wattmeter for measuring the power taken up, say, in an incandescence lamp, the following method of joining up should be adopted. (Fig. 9.)

Let M^1 M^2 be the mains, and let L be the lamp. The lamp should, as usual, be put in series with the thick wire coils, T. The fine wire coils, F, should have their terminals joined, not to the two terminals of the lamp, but to the terminals of the lamp and the thick wire coil as joined in series. The thin wire coil thus measures the potential at the extremities, not of the lamp, but of the lamp and thick wire coil in series. The reason f
is as follows :—Suppose the thick wire coil to have a resis
of ·01 ohm and the thin wire coil to have a resistance of
ohms, and apply this Wattmeter to measure the power cons
in two lamps, each of 8 candle-power, and requiring, s
watts—but in one case let the lamp be a 100-volt lamp t
·2 ampere, and in the other a 10-volt lamp taking 2 am
If the fine wire coil is joined in parallel with the lamp alo
the case of the high volt lamp, since the resistance is 500
hot, the lamp will take two-thirds of the whole current f
through the thick coil—in other words, the current which
through the thick coil is not that flowing through the lamp, bu
through the combined resistance of lamp and fine wire coil
however, the same wattmeter is applied to measure the po
the low volt lamp, then, since the hot resistance of this is
ohms, the lamp will get 1000/1005ths of the current f
through the thick coil. It follows from this that whereas t
lamps consume exactly the same power, yet, in the first cas
current in the thick coils, which is that which actuates and
of the factors in determining the reading of the wattme
half as great again as it should be. It would be found t
the case of the high volt lamp the wattmeter reading wo
30 watts, and in the case of the low volt lamp 20 watts, alt
both lamps actually take the same power. If, however, t
tremities of the voltmeter, or movable or fine wire coil
joined, as shown in Fig. 9, then the current in the thick
exactly that through the lamp, the error in the electro
force part of the measurement is then only dependent on t
that the thick wire coil has an appreciable resistance ; if t
only ·01 ohm, the error made in the electromotive force p
the measurement is only ·1 per cent., even in the case
low volt lamp, by assuming the potential at the extremit
the lamp and thick coil in series as equal to that at the ter
of the lamp.

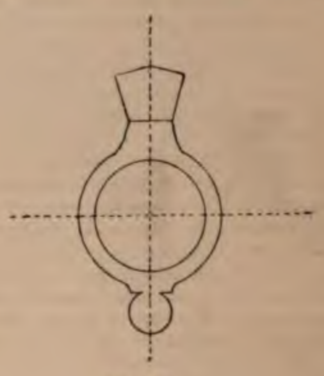


FIG. 6.

Unless the resistance of the current coils is vanishingly
compared with that of the high resistance or movable coil
above method of joining up the wattmeter does not give t
rate of dissipation of energy in the lamp or other circuit
consideration.

Let us examine the theory of the instrument a little
closely. Let R (Figs. 10 and 11) represent the resistance
thick wire or current coils, and let r represent the resista
the fine wire or volt coils, and let ρ stand for the resistance
lamp or other circuit in which the dissipation of energy is
measured. Given the ends of these thick and thin wire
we may then join them up to the lamp in either of two w
shown in Figs. 10 and 11.

What we actually do in the use of a thick and thi
electro-dynamometer, employed as a wattmeter, is to m
the products of the strengths of the currents in the thic
thin wire coils respectively, by measuring the electro-d
attraction between these circuits when held in certain
positions. If, however, the circuits are joined up to a lam
Fig. 10, although the current in R is equal to the current t
the lamp, yet the current through r is not proportional
difference of potentials on either side of the lamp, but
by an amount which depends on the ratio of ρ to R.
represents the true watts taken up in the lamp under m
ment, and W_1 represents the observed watts by the dynamo
on the assumption that it has been calibrated for one pa
lamp of very high resistance compared with R, then

$$W_1 = W\frac{\rho + R}{\rho} \quad . \ . \ . \ . \ . \ .$$

for W_1 is made up of two factors—one a number proporti
the current in R, which is the current through the la
another factor which is proportional to the difference of
tials over all between the outside terminals of lamp and
ance R.

This last is greater than the potential difference on eith
of the lamp, in the ratio of $R + \rho$ to ρ.

Next, let the fine wire coils be joined to the terminals
lamp as in Fig. 11. The current in r is now proportional

* *Paper read before the Society* of Telegraph-Engineers and Elec-*tricians.*

potential difference on either side of the lamp. The current in the thick wire coils is not, however, identical with that through the lamp, but equal to that through the lamp and fine wire coils together. If c stand for the current through the lamp, and C for the current in the thick wire coil R, then

$$c = \frac{r}{r+\rho} C,$$

and accordingly, if, as above, W stand for the true watts

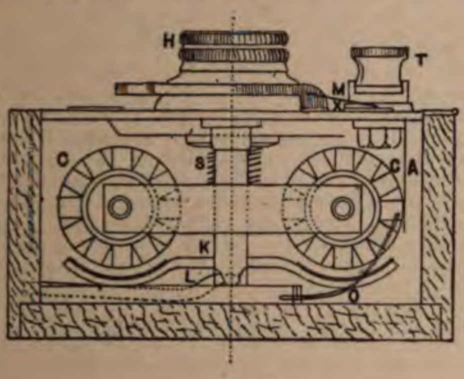


FIG. 7.

expended in the lamp, and W_2 for the watts as observed on the dynamometer, we have the relation

$$W_2 = W \frac{r+\rho}{r} \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(ii.)}$$

From equations (i.) and (ii.) we have

$$W_1 \rho = W\rho + W R,$$
$$W_2 r = Wr + W \rho ;$$

hence,
$$W^2 \frac{R}{r} = (W_2 - W)(W_1 - W) ;$$

or,
$$W^2 - \left(\frac{r}{r+R}\right)(W_2 + W_1) W + \left(\frac{r}{r+R}\right) W_1 W_2 = 0.$$

The solution of this quadratic equation gives W.

It is not difficult to show that this quadratic equation always has one real positive root, since r is greater than R, and W_1 and W_2 are positive quantities. We arrive, therefore, at this result: If any given wattmeter of this type has been calibrated on a lamp or other circuit of which the resistance is very great compared with the thick wire or current coils, supposing the connections made as in Fig. 10, then the observed readings of the wattmeter, when used with any other lamp or circuit, will

ohms. The thick wire or current coils are of the highest conductivity copper; and in the instrument designed as a lamp wattmeter, to read direct from 1 to 400 watts, have a resistance of about ·1 or ·2 ohm. It is intended to issue wattmeters of three grades—one reading from 1 to 400, the next from 10 to 4,000, and the highest from 100 to 40,000, and suitable for electromotive forces of 50 to 250 volts.

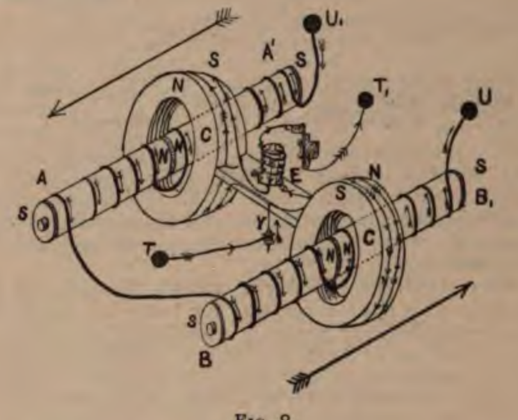


FIG. 8.

In the wattmeter above described the scale is, of course, a scale of equal divisions. In the form of instrument adapted for lamp measurements, the circular scale is divided into 400 divisions, and each division represents 1 watt. By means of a wattmeter and voltmeter of the above description, all the four electric elements of a lamp can be measured at once. Let the wattmeter be joined up as indicated in the above diagram (Fig. 10), and let, in addition, the terminals of the voltmeter be connected to the points A and B, the voltmeter then reads the potential difference of A and B, and the wattmeter reads the consumption of power between A and B. If W be the reading of the wattmeter and V that of the voltmeter, the quotient of W by V gives the current through the lamp, and the quotient of the square of V by W gives the hot resistance of the lamp. We have designed an instrument which shall be a combination of watt- and voltmeter, and enable the two measurements of potential difference at extremities of a circuit and power consumed in that circuit to be simultaneously measured, and therefore to give at once the current in the circuit and the hot resistance. In this instrument the fixed coils would be wound compound, with two coils on each, one thick overlaid by a thin wire winding.

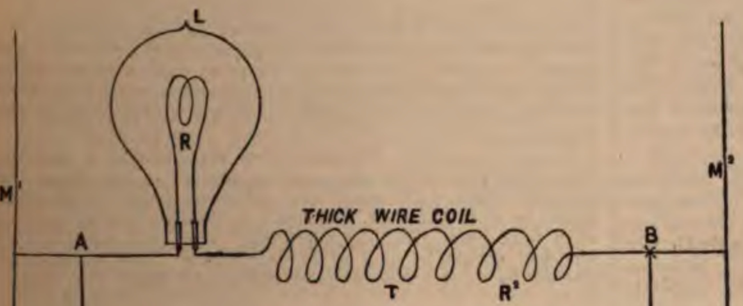


FIG. 9.

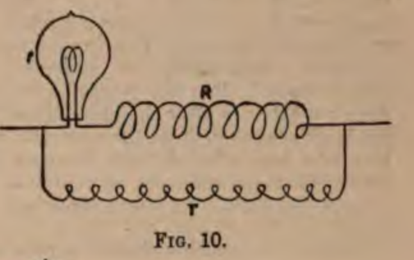


FIG. 10.

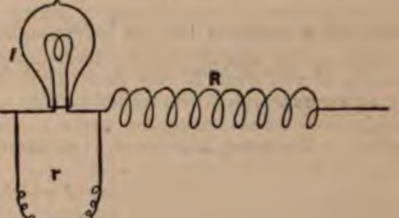


FIG. 11.

not give the true watts expended in that circuit, but give a value which is rather too high, and of which the error will depend on the value of the three resistances, R, r, and ρ. We can, however, eliminate the error, and obtain a number proportional to the true rate of expenditure of energy in the circuit ρ, by taking two observations with the high resistance coils joined up respectively as in Figs. 10 and 11. If these readings are called W_1 and W_2, the insertion of these in the quadratic equation above will enable us to find a value (W) which is proportional to the real watts, and that without knowing the resistance of the lamp being tested.

In the construction of a wattmeter of this type it is evidently important that the current coils should have as low a resistance as it is possible to secure in comparison with that of the movable or voltmeter part. In our wattmeter the fine wire coils are of German silver wire, and have a resistance of 1,000 to 1,200

The connections of the fine wire windings on the fixed coils are so arranged in conjunction with a switch, that when the switch is turned one way the solenoids have, as ordinarily arranged, a N pole at the centre of each, but when the switch is turned the other way this pole is abolished. Hence, if a current flows through these fine wire windings in series with the movable coils, then, according as the switch is set one way or the other, the current will operate the instrument or not, and that without changing its resistance or affecting the current in the movable coils. Let then the thick wire coils be traversed by a main current, and the thin wire coils by a current derived by connecting their extremities to the ends of the conductor traversed by the current through the thick wire coils. The electro-magnetic force operating to displace the movable part of the instrument will be the resultant of two forces—one due to the product of the strength of the current in the thick coil and the current in

the movable coil. This product is proportional to the power consumed in the conductor. Secondly, in addition, there is a force due to the action of the current in the fixed fine wire coils on the current in the movable coils in series with them. This force is proportional to the square of the current strength or to the square of the volts at the ends of the conductor. Hence, if the switch is turned so that both thick and thin wire fixed coils are operative, the electro-magnetic force on the movable coils is proportional to the watts added to the square of the terminal volts. If W be the power consumed in the conductor, and V the potential difference at its extremities, then this reading of the instrument will be proportional to $A W + B V^2$, when A and B are instrumental constants. Next, let the switch be turned so as to render the fine wire coils electro-magnetically inoperative, although not altering the resistance of the total fine wire circuit. In this case the reading is simply proportional to the power consumed in the conductor, or to A W. We have therefore, by two readings, the power consumed and the terminal volts of the conductor or circuit, and hence, by simple division, the current and hot resistance.

In this method of measuring a current, the movable part of the instrument is not traversed by any but a very small current, and hence the difficulty generally experienced in getting a large current in and out of a freely-moving circuit has not to be combated. In considering these instruments as permanent standards, the question obviously arises as to the permanence and perfect elasticity of the steel spring. The steel chronometer spring is made of the very best and most carefully-tempered steel. The use in chronometers justifies the statement that, when not strained beyond the limits of elasticity, and when not kept in strain for a longer time than necessary to take a reading, the elasticity is perfect. There is only one caution which should be taken in using these instruments. After taking a reading, the central index-hand should be turned back to zero before putting the instrument away. If the voltmeter is closed up and put on one side, with a permanent twist upon the spring, then a slight deformation of the spring may result, which will in time disappear, but not immediately. The elastic modulus which is brought into play in this use of a spiral spring is somewhat similar to that which is operative when a beam is bent. The spiral is not drawn out, but is twisted round and bent slightly into a smaller radius. Under prolonged strain a very slight deformation occurs, which disappears gradually on the removal of the stress, and this deformation is a function both of the stress or strain and the time under which the elastic body is submitted to that stress.

On this point we may quote the experience of Prof. W. Kohlrausch, who, in a paper in the *Electrotechnische Zeitschrift* (see *Electrician*, March 25, 1887), gives the result of prolonged experiments on the employment of spiral springs in measuring instruments. The effect of age, judging by observations on a brass spring extending over a period of seven years, may be completely neglected. Continuous and prolonged deformation produces a small amount of permanent set, so that the spring, when released, does not return to its original position, but this does not actually alter the indications of the instrument if the readings are taken from the new zero thus formed. Steel is in this case less affected than German silver. Oft-repeated but intermittent deformation, as exhibited by a spring of 90 convolutions and 2½in. long being stretched, so as to change from a length of 3in. to 9in. 200 times per minute for 400 minutes, introduced no sensible alteration into its subsequent indications.

An increase of temperature of 18deg. Fahr. raised the indications of a Siemens torsion galvanometer about one-tenth per cent., so that the reduction in elasticity of the spring is apparently almost equal to the decrease in moment in the magnet. Further experiments on loaded springs confirmed this conclusion, and showed that steel was again to be preferred to German silver. We think, therefore, that there is sufficient evidence to lead us to believe that the selection of a highly-tempered steel chronometer spring as a means of weighing the electro-dynamic attraction of coils traversed by currents will not be found to lead to appreciable errors.

Instruments with the suspension we have here designed and used are not very well suited for marine use, but we are engaged in arranging a mode of suspending the movable coil which will render the instruments independent of any levelling when in actual use.

POSTAL AND TELEGRAPH REGULATIONS.

On Friday last an influential deputation of merchants and manufacturers in Wolverhampton waited upon Mr. Raikes, M.P., at Oxley Manor, near Wolverhampton, the residence of Mr. Staveley Hill, M.P. The members of the deputation called the attention of the Postmaster-General to several anomalies connected with the postal and telegraphic regulations. They complained that orders to manufacturers and others sent by the half-penny post were charged letter-rate if any note was added. They desired that documents of a commercial *character—orders,* invoices, shipping instruction, bills of lading, &c.—should go through the halfpenny post. Owing to the varied practice, some post offices passed them and others charged them letter rate. The charge for sending telegrams from post offices through the telephone to their destination was complained of as being too high.

Mr. Raikes, in reply, alluded to the charge for registered telegraph addresses, and spoke of the decision of the department in the case of Sir B. Samuelson, who made representations on the same subject on behalf of the Associated Chambers of Commerce last April. It was explained that, while the original fee of £1. 1s. was not unreasonable, the annual payment of 5s. afterwards was unequal to the cost incurred. The department did not propose to take any steps in the matter, because cypher messages not only caused delay in their despatch, but also delayed the delivery of fully addressed messages. The department was inclined to believe that the advantages gained by persons who had registered addresses were gained at the expense of the general public. Then as to the question of surcharges on invoices, &c., sent through the halfpenny postage, the whole question turned on what was the actual definition of a letter. It seemed to him that anything which was "particular" was in the nature of a letter and anything which was general was in the nature of a circular A mere invoice would pass through the halfpenny postage, but the notes and annotations added to them, either in writing or printed matter, were regarded as being in the nature of a letter. The practice varied very much. He should, however, be very glad to hear any suggestions which would place matters on a more regular and uniform basis. The specific complaint in one case submitted to him was that a firm of merchants had printed on a circular order, "The above order for samples most urgent; say first post certain when can be sent." That note was of a particular character, and in the nature of a letter. The department was very anxious to facilitate trade, but he could not hold out any hope of interfering with the penny postage, which was the sheet anchor of the postal revenue. The telegraphic branch was a losing one to the extent of half a million last year, and the department also lost on the carriage of newspapers to foreign countries. The Post Office made a profit of about 2½ millions per year on the whole, and that was a very valuable source to which the Chancellor of the Exchequer looked for revenue towards defraying the national expenditure. He had no statistics by which he could say whether the department realised any profit on the commercial letters alone. With regard to the sale of postcards at 8d. per dozen, that was a matter requiring consideration, and as to the issue of halfpenny commercial envelopes, that was a matter which should receive attention. Then, with respect to the telephone, he agreed that the position of telephoning was unsatisfactory, and was due to various causes. He thought one of the principal causes was the generosity of his predecessor, the late Mr. Fawcett, whose statements had been interpreted in the direction of non interference with the rights claimed on behalf of the telephone companies. He thought that before long steps must be taken to place telephony on the same footing as telegraphy, either under the control of the Government or entirely with private enterprise. He did not think that the present system could be justified. With regard to the payment of £5 per year for the right of having telegraph messages sent to a private house from the post office through the telephone, he did not think that that was an extravagant sum for gentlemen who wished the luxury. However, the question was one which had better be left with the Government to deal with. He pointed out that in this country the facilities for telegraphing were much greater than on the Continent, and that was perhaps one reason why so much use was made of the telephone on the Continent, and why telegraphs were more popular in this country. In conclusion, he said he should be very happy to receive suggestions which would assist the department in making the regulation clearer as to what was the nature of a letter. That was the main principle to be recognised, and the department desired to cause the least inconvenience to the general public. He quite agreed that there were disadvantages in the delivery of telegrams to places situated at long distances from the post offices. He could not, however, promise that anything should be done this year, nor could he promise that he would be in office next year. He fully appreciated what had been placed before him, and should be glad of any suggestion which would assist in placing the whole system of telephony in this country on a satisfactory basis.

The deputation then thanked Mr. Raikes, and withdrew.

LEGAL INTELLIGENCE.

GAULARD AND OTHERS v. SIR COUTTS LINDSAY AND CO. AND FERRANTI.

This was an appeal from a decision of Mr. Justice Kekewich. The action was brought by Messrs. L. Gaulard and J. D. Gibbs and the National Company for the Distribution of Electricity by Secondary Generators (Limited) against Sir Coutts Lindsay and Co. (Limited) and Sebastian Ziani de Ferranti to restrain the infringement of five letters patent of the plaintiffs. On the 21st of November Mr. Justice Kekewich, in the matter of a petition presented by Ferranti for revocation of one of the patents, made an order giving the plaintiffs liberty to apply at the Patent Office to amend the specification of that one of the letters patent. The plaintiffs afterwards moved for liberty to apply at the Patent Office to amend the same specification by way of disclaimer, correction, or explanation, and that in the meantime the trial of this action might be postponed, and that the specification, when amended, might be used in evidence at the trial on such terms as the Court might think fit. The application was made under section 19 of the Patents, Designs, and Trade Marks Act, 1883, which provides that "in an action for infringement of a patent, and in a proceeding for revocation of a

patent, the Court or judge may at any time order that the patentee shall, subject to such terms as to costs and otherwise as the Court or judge may impose, be at liberty to apply at the Patent Office for leave to amend his specification by way of disclaimer, and may direct that in the meantime the trial or hearing of the action shall be postponed." Mr. Justice Kekewich was of opinion that it would be unreasonable to allow a postponement of the action as to all the patents. And he said that if the plaintiffs would not accept the defendant's offer, that the plaintiffs should discontinue the action as to the one patent and pay the costs as to that, the motion must be refused with costs. These terms being refused by the applicants' council, the motion was accordingly refused with costs. The plaintiffs appealed.

Before the conclusion of the arguments the plaintiffs consented to the order which they asked being made upon the following terms (which the defendants were willing to accept):—That the plaintiffs should pay all the costs of the action up to the present time, and that they should not claim any relief in respect of anything done by the defendants before the amendment of the specification. The defendants to have liberty to amend their defence and particulars of objection.

Lord Justice Cotton said that a long and learned argument had taken place upon the construction of section 19; but, as both parties had assented to terms, he would give his judgment very shortly. In the case of "Bray *v.* Gardner," Mr. Justice Stirling had given liberty to the plaintiffs to apply for leave to amend their specification on the terms that the amended specification should not be used in the pending action. The Court of Appeal said that liberty to make such an application ought not to be given under section 19, unless it could be given without injustice to the defendant. But the Court did not say that the terms then imposed ought to be imposed in every case. In the present case Mr. Justice Kekewich thought the other terms should be imposed, But the appellants had now offered terms which his lordship thought would do complete justice in the present case. This offer had not been made in the court below. As the plaintiffs were asking for an indulgence, they must pay the costs of this application in both courts.

Lord Justice Lindley agreed. He did not think there was any difference between "Bray *v.* Gardner" and "Allen *v.* Doulton." In every case the Court must see what would be right and just.

Lord Justice Bowen also concurred. He desired to point out that what had been said by Lord Justice Cotton in no way narrowed the construction of the Act. When an act of Parliament had vested a discretion in the Court, the Court never wished to limit that discretion by laying down rules as to the way in which it was to be exercised. The discretion was given to the Court. The language of section 19 appeared to indicate that terms were to be imposed by the Court, if it should think the justice of the case required that they should be—that is, in order to prevent injustice being done to the one party by the indulgence which was granted to the other. That was exactly what was laid down in "Bray *v.* Gardner."

PROVISIONAL PATENTS, 1888.

JANUARY 20.

924. **Improvements in measuring and recording apparatus.** James Grieve Lorrain, Norfolk House, Victoria Embankment, London, W.C.

925. **New or improved measuring and recording apparatus.** James Grieve Lorrain, Norfolk House, Victoria Embankment, London, W.C.

JANUARY 21.

932. **Improvements in the construction of portable primary batteries adapted to medical and other appliances.** Robert Henry Thomas, 1, Hillmarton-road, Camden-road, N., and Benjamin William Warwick, 134, Highbury-hill, N.

933. **Improvements in contact regulators for electric clocks.** Ferdinand Bosshardt, 8, Quality-court, London. (Louis Bouchet, France.)

977. **Improvements in apparatus for signalling upon railway trains in motion.** James Ashton, 4, South-street, Finsbury, London.

980. **An improvement for the construction of electric battery cells for lighting or other purposes.** William Balch, 32, Elderfield-road, Clapton Park, E.

981. **Improvements in electric "call" signal apparatus.** Charles Spratt, 24, Southampton-buildings, London, W.C.

JANUARY 23.

984. **Improvements in controlling railway signal levers by the application of electricity.** William Frederick Burleigh, 106, Camberwell New-road, S.E.

985. **Improvements in interlocking apparatus for railways.** William Frederick Burleigh, 106, Camberwell New-road, London, S.E.

1009. **Improvements in dynamo-electric machines.** John Hubert Davies, 3, Burry-terrace, Westbourne-square, Paddington, W.

1016. **An improvement in electrical transforming apparatus.** Alfred Mills Taylor, 28, Southampton-buildings, Chancery-lane, London, W.C.

1024. **Improvements in and connected with electric coils.** Lazarus Simon Magnus Pyke and Harry Theodore Barnett, 433, Strand, London.

1029. **Improvements in rotary galvanic batteries.** Alfred Wunderlich, 18, Buckingham-street, Strand, London, W.C.

JANUARY 24.

1055. **An electric safety apparatus.** Reginald John Jones and Arthur Wright, "Lily Lodge," Vale of Health, Hampstead, N.W.

1078. **Improvements in switches for making and breaking electrical circuits.** Sigmund Bergmann and John Thomas Dempster, 23, Southampton-buildings, Middlesex.—(Complete specification.)

1091. **An improvement in or connected with counting or recording mechanism and electricity.** Alfred Aird, 166, Fleet-street, London.

1100. **Improvements in electrical brazing and soldering.** George Downing, 8, Quality-court, Chancery-lane, Middlesex. (E. Blass, Germany.)

1103. **Improvements in apparatus for communicating signals on railway trains.** Patrick Daley, 28, Southampton-buildings, Chancery-lane, London, W.C.

1105. **Improvements in the means or appliances for treating sewage by electrolytic action and for disposing of the deposits thereof.** William Webster, Junior, 28, Southampton-buildings, Chancery-lane, London, W.C.

JANUARY 25.

1128. **Improvements in galvanic batteries.** Alphonse Alexandre Fortin, 53, Chancery-lane, London.

1173. **Improvements in electric induction apparatus.** Bernhard Scheithauer, 18, Buckingham-street, Strand, London.

JANUARY 26.

1177. **Improvements in means for supporting or suspending elements in electric batteries.** Eason Edwin Mandeville, 31, Rosoman-street, Clerkenwell, Middlesex.

1210. **Reversible chlorine batteries.** Emile Andreoli, 62, Loughborough-park, S.W., Surrey. (Pierre Anatole Fichet and Albert Louis Camille Nodon, France.)

COMPLETE SPECIFICATIONS ACCEPTED.

JANUARY 17, 1887.

747. **Means or apparatus to be employed in the application of electricity to propel vehicles on roads with or without tram or other rails.** Frank Wynne, 46, Lincoln's Inn-fields, W.C.

JANUARY 21, 1887.

949. **An electrical switch or circuit closing and interrupting device of improved construction.** Gerald Percival, 30, Old George's-street, Cork.

FEBRUARY 16, 1887.

2419. **Improvements in dynamo-electric machines.** Ferdinand Bosshardt, 8, Quality-court, London. (August Louis Hillaire-Desbois, France.)

MARCH 26, 1887.

4546. **Improvements in dynamo electrical machines in combination with motor engines.** Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London, W.C. (The Firm of Siemens and Halske, Germany.)

4553. **Improvements in electric telegraph apparatus.** William Dickenson, 24, Southampton-buildings, London.

APRIL 2, 1887.

4914. **Improvements in switches for making and breaking electric circuits.** Robert Daniel Smillie, 87, St. Vincent-street, Glasgow.

MAY 25, 1887.

7530. **Improvements in electrical transformers.** John Grice Statter, Norfolk House, Norfolk-street, Strand, W.C.

NOVEMBER 18, 1887.

15,858. **Improvements in dynamo-electric machines and electro-motors.** William Main, 169, Fleet-street, London.

NOVEMBER 22, 1887.

16,032. **Improvements in electro-motors and dynamo-electric machines.** William Main, 169, Fleet-street, London.

SPECIFICATIONS PUBLISHED.

1886.

15,344. **Automatic switch and governor for electric lighting purposes.** A. M. Clark (The Elektrotechnische Fabrik Cannstatt.) 8d.

16,865. **Coupling up batteries for lighting, &c.** L. R. Davies and M. Shearer. 8d.

17,120. **Dynamo-electric Machinery.** R. E. B. Crompton and J. Swinburne. 8d.

1887.

3998. **Applying electric light for photographic purposes.** F. J. Chary. 8d.

15,099 **Type-printing telegraphs.** A. Le N. Foster and W. S. Steljes. 1s. 1d.

16,406. **Telegraphic transmission, &c.** P. B. Delany. 11d.

16,424. **Telegraphic Instruments.** W. P. Thompson (Burke). 8d.

16,476. **Telegraph, &c., poles.** W. Bayliss and E. Jones. 4d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.	Dividend.		Name.	Paid.	Price. Wednesday
3 Jan.	4%	African Direct 4%	100	98 to 100	1 Sept.	5%	Gt. Northern 5% Deb., '83.	100	105
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼	25 July	10/0	India Rubber, G. P. & Tel.	10	22¼
12 Feb.	2/0	— fully paid	5	4 5-16	28 Oct.	12/6	Indo-European	25	39
28 Oct.	7/6	Anglo-American	100	40	16 Nov.	2/6	London Platino-Brazilian...	10	5
28 Oct.	15/0	— Pref.	100	66	16 March ...	5%	Maxim Western...............	1	¼
12 Feb., 85...	5/0	— Def........................	100	14¾	15 May	5%	Oriental Telephone	11	⅜
29 Dec.........	3/0	Brazilian Submarine.........	10	12	14 Oct.	4/0	Reuter's	8	8½
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	3½	1⅝
28 July	8/0	Cuba	10	12¾	28 July	12%	Submarine	100	135
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	97
14 Oct.	1/0	Direct Spanish	9	4¼	14 July	12/0	Telegraph Construction ...	12	39
18 Oct.	5/0	— 10% Pref.	10	9½	1 July	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	8⅞	30 Nov.	5/0	United Telephone	5	13¼
12 Jan.	2/6	Eastern	10	11½	......	...	West African	10	5
12 Jan.	3/0	— 6% Pref.	10	14¾	1 Sept.	5%	— 5% Debs.	100	93
2 Aug.	5%	— 5%, 1899	100	109	29 Dec.........	6/0	West Coast of America ...	10	5 5-16
28 Oct.	4%	— 4% Deb. Stock	100	104½	31 Dec.	8%	— 8% Debs.	100	115
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12⅛	14 Oct.	3/9	Western and Brazilian......	15	9
					14 Oct.	3/9	— Preferred	5½	6¼
2 Aug.	6%	— 6% Deb., 1891	100	109	......	...	— Deferred..................	2½	3 1-16
3 Jan.	5%	— 5% Deb., 1900	100	105x	2 Aug.	6%	— 6% A	100	110
2 Nov.	5%	— — 1890	100	102	2 Aug.	6%	— 6% B	100	107
3 Jan.	5%	Eastern & S. African, 1900	100	104½	......	...	West India and Panama ...	10	1
12 Jan.	5/9	German Union	10	9¾	30 Nov.	...	— 6% 1st Pref.	10	10
14 Oct.	0/6	Globe Telegraph Trust......	10	5⅞x	13 May, '80...	...	— 6% 2nd Pref.	10	6½
14 Oct.	3/0	— 6% Pref.	10	13½	2 Nov.	7%	West Union of U.S..........	$1,000	125
3 Jan.	5/0	Great Northern...............	10	14x	1 Sept.	6%	— 6% Sterling	100	105

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Dec. ...	£38,908	– £1,631
Brazilian Submarine	F. Jan. 20 ...	£6,902	...	Great Northern	M. of Dec. ...	21,600	...
Cuba Submarine	M. of Dec. ...	3,300	+ £175	Submarine	None	Published.	
Direct Spanish.....................	M. of Dec. ...	2,004	+ 222	West Coast of America	M. of Dec. ...	4,300	...
— United States	None	Published.	...	Western and Brazilian	W. Jan. 20 ...	1,722	...
Eastern..............................	M. of Dec. ...	57,703	+ 4,880	West India and Panama	F. Jan. 15......	2,509	– 467

Abbreviations: W., week; F., fortnight; M., month.

NEW ELECTRICAL COMPANIES, 1887.

Name of Company.	Capital Authorised.	Capital Offered.	Amount of Shares.	Deposit.	Total Deposit.
Blockley Electric Lighting and Manufacturing..................	£20,000	...	£5 0 0	...	...
Eclipse Electric Battery, Limited	100,000	£100,000	1 0 0	£0 10 0	£50,000
Electric Battery Brush, Limited	50,000	50,000	5 0 0	1 0 0	10,000
Extended Electro-Metal Extracting, Refining, and Plating, Limited	150,000	150,000	1 0 0	0 5 0	37,500
Jensen Electric Bell and Signal, Limited	100,000	100,000	1 0 0	0 6 0	37,500
Orient Electric Light..................	5,000	...	250 0 0	...	...
Platinum Plating, Limited	60,000	59,100	1 0 0	0 5 0	14,775
Portland Electric Light..................	45,000	...	5 0 0	...	...
Singapore, Straits Settlements, and Siam Electrial, Limited..................	60,000	39,000	5 0 0	2 0 0	15,600
South Metropolitan Electric Supply	250,000	...	10 0 0	...	...
St. James's Electric Light, Limited	50,000	50,000	5 0 0	2 0 0	20,000
Union Electrical Power and Light, Limited	500,000	125,000	5 0 0	2 0 0	50,000
Winfields, Limited..................	160,000	120,000	5 0 0	3 0 0	72,000
Woodhouse and Rawson, Limited	200,000	105,000	5 0 0	1 0 0	21,000

CITY NOTES.

The Consolidated Telephone Company.—We are informed that Mr. J. H. Buckingham, of Wood-street, Cheapside, has joined the Board of the Consolidated Telephone Construction and Maintainance Company.

Western and Brazilian Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the week ending January 13, after deducting one-fifth of the gross receipts, payable to the London Platino Brazilian Company, were £2,875.

Anglo-American Telegraph Company.—The directors' report of this company for the half-year ended 31st December states that the *total receipts from the 1st July to the* 31st December, 1887, including *the estimated balance of £18,323. 6s.* 8d. brought forward from the last account, are estimated at £113,283. 6s. 5d. This amount, however, is subject to revision upon settlement of the accounts for the year with the Paris-New York Telegraph Company, The traffic receipts show an increase of £9,460 as compared with the corresponding period of last year. The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £49,688. 8s. 1d. Interim dividends of 7s. 6d. per cent. on the ordinary stock, and 15s. per cent. on the preferred stock, were paid on the 1st November last, absorbing £26,250, leaving an estimated balance of £37,344. 18s. 4d., out of which the directors recommend the proprietors to declare final dividends of 10s. per cent. on the ordinary stock, and 20s. per cent. on the preferred stock, amounting to £35,000, making a total distribution for the year ended the 31st December, 1887, of £1. 7s. 6d. per cent. on the ordinary stock, and £2. 15s. on the preferred stock, leaving an estimated balance of £2,344. 18s. 4d. to be carried forward to the next account.

NOTES.

Stockholm.—The Royal Palace is lighted throughout by electricity.

Dividend.—The Taunton Electric Lighting Company, at their first annual meeting on Monday last, declared a dividend of 5 per cent., and a balance was carried over.

Paris Municipality.—At a recent meeting the Municipal Council of Paris, after a long discussion, voted the sum of one million of francs, which the Commission of the Budget had decided to devote to the creation of a municipal service for electric lighting.

Electric Lighting in Paris.—The Continental Edison Company has just completed the electric lighting of the Grand Hotel by an installation of 800 incandescence lamps, which are located in the grand saloon, the Zodiac saloon, the reading rooms, and the restaurant, and are worked by two Edison dynamos.

Aerial Conductors.—According to there searches of M. Guglielmo, of the Turin Academy, no loss of electricity takes place through moist air, surrounding an uncovered wire, until the difference of potentials reaches 600 volts. Above this critical tension the loss augments with the voltage and with the degree of humidity of the air.

A Prospective New Chemistry.—Dr. Grunwald, of Sprague, has arrived, by spectroscopic evidence, at a conclusion already supported by the names of Mr. Norman Lockyer and Mr. Crookes, viz., that certain of the supposed simple bodies or elements are in reality of a highly complex nature. His researches have extended to hydrogen, oxygen, carbon, and magnesium.

Glasgow Exhibition.—The electric lighting of this exhibition, as is well known to our readers, is in the hands of the Brush Company, who are utilising the plant recently used at Manchester for a similar purpose. The dynamo shed forms an annexe to the machinery section, and is 118ft. long by 100ft. broad. The lighting arrangements are being actively carried forward.

Electricity in Finland.—Electric lighting and the telephone have been taken up with some enthusiasm in Finland. Two little towns, with a population of 2,000 each, have adopted electric lighting; whilst the telephone is in operation not only in the towns, but in the country. Helsingfors and Abo, at a distance from each other of 112 versts, are connected by a telephonic wire.

St. Pays.—The President of the Van Depoele Electric Tramway at St. Catherines states that the electric cars took in double what the horse cars did when running over the same line, that the business of the road has already increased by 35 per cent., that five electric cars do the work of eight horse cars. Also the cars are kept cleaner, and the drivers and conductors take an interest in keeping them so.

The Telephone in Russia.—Telephonic lines are being established at Ribinsk, and in the arrondissement of the same name. The municipal hospital and several private houses are already in connection, and the Juravlef factory, at two versts from the town, is in communication with its office at Ribinsk; whilst the suburban residences of several merchants are being connected with their business premises in the town.

Board of Trade License.—Notice is given in the *Gazette* that application has been made by the Kensington Court Electric Lighting Company, under the Lighting Act of 1882, for license to produce and distribute electricity, power to make charges, to acquire lands, to construct works, to make arrangements with local authorities to open streets and lay electric lines, over a certain district defined in the license, around their station.

The Electric Light in Mines.—The *Forges et Houillères* Company of the Aveyron is about to establish electric lighting in all the works at one of their most important concessions situated at Combes. The motive power required will be supplied by the steam engines already in use. If the result of this experiment is satisfactory, the same system of lighting will be adopted in all the other concessions of the Company.

Electric Gas Lighters.—The lighters in which a platinum wire is raised to incandescence by the current from chloride of silver cells are well and favourably known to the public; but Messrs. Woodhouse and Rawson have improved upon this form, and have introduced a lighter in which the required current is obtained by a magneto generator worked by a spring. The advantage of this form is immediately seen. It involves no battery or chemicals. The only question, perhaps, is how will damp affect it?

Cost of Electric Lighting.—The following comparative estimates of the cost of lighting Chicago are taken from a report by Prof. Barrett. It must not, however, be assumed that these figures are true everywhere. The cost of gas is not the same at one place as in another, and unless the cost of gas is given figures are apt to be misleading :—

	No. lights.	Candle power.	Cost per year.
Gas	3,273	52,368	$12,351
Arc lights	750	1,500,000	$7,180
Incandescent lights	3,273	98,190	$9,346

Society of Antiquaries.—We are pleased to learn that the Society of Antiquaries has availed itself of the advantages offered for the utilisation of the Royal Society's gas engine plant during free hours, and has installed a total of 110 16 candle-power lamps throughout its premises. The spare power is stored in 33 of Drake and Gorham's improved type cells capable of discharging at 60 amperes for about nine hours. Switchboards of the same firms' latest design, and fitted with the patent ring contact switches, are employed for governing the main circuits.

Royal Meteorological Society.—The council of the Royal Meteorological Society have arranged to hold at 25, Great George-street, Westminster (by permission of the Council of the Institution of Civil Engineers), on March 20th to 23rd next, an exhibition of apparatus connected with atmospheric electricity, including lightning conductors, photographs of lightning, and damaged objects. The committee will also be glad to show any new meteorological instruments or apparatus invented or first constructed since last March; as well as photographs and drawings possessing meteorological interest.

Subways.—Our American contemporary, the *Electrical World*, calls attention to one of the dangers of subways through the leakage of gas in places where the gas-mains are adjacent to subways. It is almost certain that sooner or later the subway will be filled with gas, and unless great care is taken accidents will arise, either by the gas being inflamed, or, as was the case at Philadelphia, a man working in the manhole being—shall we say—poisoned. Our friends connected with the gas journals are very quiet over many of the dangers which exist in the usage of gas, and which do occasionally bring about bad results. We have referred to one of them.

Electric Lighting in Spain.—The Schuckert Company are carrying out the electric lighting of the Royal Opera at Madrid, in accordance with the decisions of the municipality. The installation will comprise 1,500 incandescence lamps and a dozen Krisik arc lamps. The Bilbao municipality have voted for the electric illumination, by means of 32 arc lamps, of the main promenade in the town. The motive-power will be supplied by the steam engines actually in use at the waterworks. The progress of electric lighting in Spain is evidenced by the fact that the little town of Albacete, with a population of only 20,000, is to be lighted with 16-candle incandescence lamps; many of these being also supplied to private individuals.

Early Telegraphy.—In the *Civil Engineer and Architects' Journal* of the date January, 1847, there occurs the following paragraph—"The South-Eastern Railway Company have exhibited their confidence in this invention by making preparations to lay down an electric telegraph from Folkestone to Boulogne." It seems certain, after all that has been written, the early history of telegraphy is not well known. The unfortunate part is that those who could give interesting and authentic history are passing from us one by one, leaving the details untold. Who can give any information about this scheme of the South-Eastern Railway? Was it the original idea which culminated in the success of Brett, Crampton, & Co., or was it another scheme altogether?

Trade Conferences.—A series of conferences of the representatives of various trades and handicraft industries is now being held at the Finsbury Technical College. These began last autumn with two general conferences on technical education. The third conference, which was for the cabinet-making trade, and was attended by a large and very representative audience, was held on January 14th last. The next conference, which is for bricklayers, is to be held on Wednesday, February 15th, when Mr. James Rowlands, M.P., will preside, and a paper on the Technical Education of Bricklayers and Brickcutters will be read by Mr. H. W. Richards. This will be succeeded on the 18th inst. by another conference of carpenters and joiners, under the presidency of Mr. W. R. Cremer, M.P.

Smelting by Electricity.—Although numerous inventors have attempted to substitute electricity for coal and coke in metal smelting, nothing practical has yet come of these attempts. Siemens, Huntingdon, Cowles, and others have experimented with the dynamo, and the Cowles process for obtaining aluminium is, perhaps, the only commercial application as yet successful. There should be room for good work in this direction. As far back as the British Association meeting in 1847, attention has been directed towards the utilisation of electricity in these processes. Sir R. Inglis, in his address at this meeting, referred to successful laboratory experiments, but dwelt strongly upon the fact that the process which proved successful in the laboratory and in dealing with ounces was not necessarily successful in the manufactory and in dealing with tons.

Polarisation.—F. Strenitz, continuing his experiment on polarisation, finds that with silver the oxygen plate is found to attain maximum polarisation when the E.M.F. of the cell is equal to that of three Daniells; the polarisation of the hydrogen plates is at a maximum when an E.M.F. of two Daniells is used, it decreases when a greater E.M.F. is employed, but rises again and becomes equal to the first maximum for an E.M.F. of nine Daniells. The explanation given is that the deposition of metallic silver on the cathode, which is greater the greater the intensity of the current, by increasing the surface decreases the relative strength of the current and the amount of the polarisation; so that although a small E.M.F. produces maximum polarisation with clean plates, a very considerable one is required to attain the same maximum with plates thickly coated with silver.

Sprague Motors.—The use of this motor has been adopted at a sugar refinery at Boston. The cars run all day, and the load averages 10 tons per trip. Horses used to do the work, and the trip occupied 15 minutes; with electricity it occupies five minutes. The gross load is 15 tons, including the car. We could fill our note columns with confirmation concerning the successful use of electrical traction in America, but we are tempted to ask, What is the use? One of the oldest, most experienced, and open-minded of tramway engineers, discussing electrical *v.* horse traction, put the case of the directors of companies very pointedly. He said:—"They know now where they are; forage is cheap, and they can pay from 5 to 7 per cent." What more do you want? We have not great expectation that the older lines will change, but what about newly projected lines?

Submarine Telegraph Cables.—In the sitting of the Budget Committee of the Reichstag on February 8th, during the discussion of the proposed purchase of the telegraph cables between Borkum and Lowestoft and Greetsiel and Valencia, Dr. von Stephan, the Prussian Postmaster-General, declared that it was intended to make a considerable reduction in the telegraph rates between Germany and England after the agreement on the subject had come into force, which would be on January 1st next. The charge for the Grundtaxe, at present amounting to 40pf., would be abolished, and the rate per word, which is at present 20pf., would be reduced to 16pf. The Minister added that the British Government would take over the Borkum-Lowestoft line, and establish direct communication with London and the more important towns of England. The agreement was unanimously approved by the committee.

The Electric Light in Belgium.—The trial installation of the electric light at the National Bank, Brussels, has been so satisfactory that it has been decided to dispense with gas altogether, and the new illuminant is to be introduced in the dépôts and treasuries by M. Léon Gérard. The establishment of a syndicate for the development of electric lighting, which would include the name just mentioned, as well as that of M. Mourlon and the *Société Industrielle d'Electricité*, is spoken of in Brussels. Elsewhere in Belgium great activity prevails in this direction. Amongst the installations in progress may be specially mentioned that at the zinc rolling mills of the Vieille Montagne Company, at Tieff, with 24 arc and 100 incandescent lamps, that in Mellaerts Sugar Works at St. Trond, and that in the spinning mills of M. Albert Oudin at Dinant, all three being carried out by the firm of Bouckaert at Brussels.

Edmondson's Calculating Machine.—Some of our readers who have much to do with figures, and especially with the multiplication and division of large numbers, might do well to follow the example of Mr. T. A. Edison, who has just obtained one of the new circular Arithmometers for use in his laboratory at Orange, New Jersey. The new machine possesses important advantages over those of less recent construction, multiplying and adding, or multiplying and subtracting in one operation, in the time which would be occupied in multiplying alone, *i.e.*, in so short a

time that even a practised computor can scarcely find the required logarithms in the same period. In many cases it may be an important advantage to relieve the brain of the drudgery of computation, and to substitute for this the mere arrangement of the figures and the working of the machine, which is in reckoning what the sewing machine is in needlework.

Belief in Electric Traction.—"I expect," says the president of a tram line at Washington, "to see horses altogether banished from the street car service in the next two years, and their place taken chiefly by electricity." George Westinghouse, jun., says: "The results of a comparatively short experience in the use of electricity as a motor for surface railway cars have been such as to demonstrate beyond question its immense superiority for this purpose over any other known method of applying power. Every consideration of efficiency, convenience, and economy, not to speak of humanity, urges the substitution of mechanical for animal power upon the numerous street railway lines of the country, at the earliest practical moment; and in the contest for superiority in the various more or less successful methods of applying mechanical power to this purpose, such as the steam locomotive, the traction cable and the electric motor, the last named is at the present moment generally admitted by those most competent to judge to be distinctly in advance of all competitors."

Electric Lighting in France.—The electric light has just been introduced in the offices of the Administration of State Railways, Rue de Châteaudun, Paris.—A plan of electric lighting for the town of Versailles is under consideration. Motive power would be derived from the machines at Marly; this portion of the scheme necessitating an interesting application of the electrical transmission of energy. The matter is in the hands of a company which is being established to work electrical apparatus produced at the Oerlikon workshops.—The Clermond-Ferrand Gas Company has just carried out an installation of the electric light at the theatre in this town; it will comprise 150 Edison lamps.—The Montpellier theatre is to be lighted by electricity. In virtue of a recent decision of the municipal council of this city, a contract has been entered into between the municipality and M. Victor Popp for the lighting both of the *salle de spectacle* and of a portion of the highway at Montpellier. The motive power is to be transmitted by means of compressed air.

Cum Grano Salis.—A waste product of an important chemical process, says the *Electrical World*, is a liquid as colourless as distilled water, but twice as heavy. This is claimed by an inventor at the Mechanics' Fair, Boston, to be a valuable element in the storage battery. He has discovered that when used in place of the usual solution in the storage battery, it increases both its efficiency and its capacity for retaining its charge to an enormous degree. But not only this, the inventor was almost thunderstruck at the effect of a further experiment with the liquid the other day. "Mixing it with a certain substance whose nature he keeps secret for the present, and charging a bottle of it with electricity from a dynamo, the result has been a brilliant glow of the entire contents, a light which has lasted undiminished ever since. Thus, if the inventor's hopes are borne out, the result will be an electric lamp that may be freely transported anywhere, lasting for a long period without charging, and substantially, perhaps, perpetual." We are unpleasantly familiar with the locution, "the nature of which is kept secret for the present;" but possibly there may be *some* foundation for the above statements.

Notes on American Electric Tramways.—Mr. Ransom, writing on the comparative cost of steam, horse, cable, or electricity, takes a sample road, six miles long, with 24 cars, a speed of six miles an hour, and running 20 hours out of 24. This would require 48 horses on the lines and 192 in the stables, costing, with harness, initially about 38,400dols. The initial cost for electrical plant he estimates at 26,500dols., for cable plant 35,000dols., and for comparison these figures may be put—

A motor plant of	horses	costs ...	$38,400
" "	electricity	" ...	26,500
" "	cable apparatus	" ...	35,000
" "	steam	" ...	?

With regard to the road, the estimate is for horse road single track per mile 9,000dols.; electric varies according to system from 10,000dols. to 23,500dols.; cable roads from 30,000dols. to 110,000dols.; steam 9,000dols. If old roads have to be adapted to the new traction, the cost of adaptation is given for a six mile road: for cable 265,200dols., for electricity 70,500dols., for steam 40,000dols. In conclusion, Mr. Ransom says—"In original cost, expense of operating, cost of maintenance, outlay in applying to old roads, steam distances every other mechanical system."

Bath and Taunton.—We stated some time since that an effort would be made to introduce the electric light into Bath, a number of influential citizens having avowed their willingness to co-operate to that end. In more than one quarter we have heard a wish expressed that the efforts of these gentlemen may be successfully accomplished ere the visit of the British Association in September next. We are not in a position to give any information on the question, or to state what progress has been made, but from the position and character of the gentlemen interested we have reason to believe that they "mean business." Taunton has won considerable *éclat* by the introduction of the electric light. Speaking at a public dinner there the other day, the Hon. Percy Allsopp, the member for the borough, said that Taunton had made such rapid progress, and had become so well known, that he hardly ever took up a morning paper without seeing some account of a visit that had been made by some scientific body or well known corporation, for the purpose of seeing what Taunton alone throughout the whole of the West of England possessed. The Mayor and Corporation were to be congratulated upon having made the town of Taunton famous, not only in Somerset, but throughout England. They had succeeded in successfully introducing a most wonderful scientific improvement in the shape of the electric light, and the town after dark presented a most bright and cheerful appearance. Taunton was the first to successfully deal with one of the most difficult problems that a Corporation had to face.—*Bath Chronicle.*

Electrical Lighting Plants.—Messrs Siemens and Halske and Messrs. Ganz and Co. have designed portable electric lighting plants. The former was described and illustrated in a recent number of *Industries*, the latter is said by the same paper to differ from the former in that Messrs. Ganz employ an alternating current dynamo, and put all the eight arc lamps in series. For incandescent lighting they employ a small transformer. Power is supplied by an 8 h.p. portable engine working at 60lb. pressure, and making 130 revolutions per minute. On a platform projecting back over the fire box, and therefore over the

driver, is mounted an alternating current machine, driven direct from the fly wheel at 750 revolutions per minute. The engine and dynamo are protected by a roof against the weather. The car contains eight alternate current arc lamps suspended from flexible bars so as to protect them against jolting on the road; also a small four-wheel trolly, on which are mounted two drums containing a mile and a quarter of suitable wire; also two water butts, insulators, earth anchors, a screw jack, and an assortment of tools. The lamp posts are of wood, and are on brackets fixed to the outside of the car. The total cost of the plant was about £830. All the circuits are carried overhead, and at a recent trial one superintending engineer, one driver, one lineman, and eight labourers, erected the plant and began lighting up in seven hours, reckoned from the time when the engine and car were unloaded from the railway trucks. After finishing work, the whole of the material was again replaced, and the engine and car loaded, in four and a half hours.

City and Guilds Institute.—The following evening course of instruction has been arranged:—A special course of four lectures on the mechanical engineering involved in the design and manufacture of dynamo machines and motors, will be delivered by Prof. John Perry, M.E., D.Sc., F.R.S., once a fortnight on Thursdays at 7 p.m., commencing February 16th, together with drawing office work on the same subject on the alternate Thursday evenings from 6 to 9 p.m. It will be necessary to state the electric and magnetic rules which are now adopted by the best engineers in the construction of continuous and alternating current machines, switches, &c., but the course will be made, as much as possible, a practical course on the mechanical engineering of dynamo machines and motors. The following gives the subject of the lectures:—

February 16th.—Continuous current dynamos and motors in use described. Electric and magnetic rules which are now adopted, as to sizes of iron and the winding. The iron and other materials used. Where the mechanical engineer's usual methods of working must be modified. Journals.

March 1st.—Simplicity of design. The usual causes of a breakdown. Use of machine tools. General questions of strength of parts. Armatures. The division of metal. Insulation and winding of wire, &c., on the field magnet and armature. Lasting power and strength of joints.

March 15th.—Forces to which the wound wire is subjected. Influence of these on design of armature. The driving of dynamos direct and by gearing. Driving from motors. Commutators and brushes, their design, insulation, strength, wear and manufacture. The electric transmission of power.

April 19th.—Alternating current machines in use. Electric and magnetic rules. Design and manufacture in the past, and probably in the future as compared with that of continuous current machines. The past and probable future of dynamos.

Physical Society, Glasgow University.—Among other interesting points referred to in Mr. Andrew W. Meikle's paper on Friday, Feb. 3, the following comparison of a number of Sir William Thomson's balances, independently standardized by the electrolysis of copper sulphate solutions, were quoted. Two centi-ampere balances standardized eight months ago were at that time found to be in absolute agreement when compared with each other. These two instruments have been compared from time to time since that date with a view of checking their relative constancy, and are still in absolute agreement. Two deci-ampere balances, A and B, were also referred to. One of the above mentioned centi-ampere balances was used to determine the constant of deci-ampere balance A, while the constant of deci-ampere balance B was taken from three separate electrolytic experiments which were in very close agreement, the first differing from the second by $\frac{1}{600}$ per cent. and the second from the third by $\frac{1}{80}$ per cent. These two balances A and B when compared together showed a difference of $\frac{1}{105}$ per cent., while deci-ampere balance A is still in absolute agreement with the centi-ampere balance used to determine its constant. As regards the larger instruments, the results were equally satisfactory. Taking in the whole set of the seven standard instruments, the largest variation of constant for one instrument when compared with the one next above it was observed between the ampere and deci-ampere balances, and was then only $\frac{1}{60}$ per cent. Thus, at the time of writing there were in the Physical Laboratory of the University of Glasgow a series of standard instruments capable of measuring from half of a centi-ampere to 500 amperes, all of which were, practically speaking, in perfect agreement.

Accumulators on Tramcars.—Electrical engineers will no doubt be called upon frequently to draw up plans and estimates for tramway work, both with accumulators and direct working, hence the following figures of Mr. Huber will be of interest. He estimates that the energy required to be stored in the cells in order to draw a load of one long ton, in ordinary weather, over one mile of average road, the gradients on which do not exceed $2\frac{1}{2}$ per cent., on an average, is equivalent to 125 watts exerted for an hour. Calling the daily run 70 miles and the weight of the car eight tons, it follows that the battery must be of such proportions that it can give out during the run as much energy as is equivalent to $70 \times 8 \times 125 = 70{,}000$ watts exerted for an hour. As this energy is not used during one hour, but distributed through say 14 hours, the battery will only need to be $\frac{1}{14}$th of 70,000 watt-power, or 5,000 watt-power. If there are 125 cells, each having an E.M.F. of 2 volts, the E.M.F. of the battery will be 250 volts, and in order that it may develope the necessary 5,000 watts it must give a current of 20 amperes $(5{,}000 \div 250 = 20)$. Ohm's law $(C = E \div R)$ shows that if the current is 20 and the E.M.F. 250, the total resistance must be 12·5 ohms. Most of this resistance will be in the motor, which should be designed accordingly. It takes 746 watts to equal 1 h.-p., so that 70,000 watts exerted for one hour is the same as $70{,}000 \div 746 = 93{\cdot}8$ h.-p. exerted for an hour. We may assume that the generator gives out 80 per cent. of the indicated h.-p. of the engine that drives it. The engine would therefore be large enough to be able to exert 117·2 h.-p. for one hour, if it did the charging all in one hour, since 80 per cent. of 117·2 is 93·8. If the charging of the battery lasts 20 hours instead of only one hour, the engine need be only $\frac{1}{20}$th as large. That is, it will not need to exert more than 5·9 h.-p.

The Sunbeam Lamp.—The *Western Mail*, in calling attention to the increasing value of the electric light for mining purposes, speaks very favourably of the Sunbeam lamp, first introduced by Messrs. Clarke, Chapman, Parsons, and Co., of Gateshead-on-Tyne, at the late Newcastle Exhibition, and it is being introduced into the South Wales district by Messrs. Walker and Olliver, of Cardiff. The *Mail* says:—"A very marked advance in the progress of electric lighting has recently been made by the introduction of the Sunbeam Incandescent Electric Lamp, which is now made to give from 200 candle-power to 1,500 candle-power, as required. In appearance the Sunbeam lamp is simply a large form of the beautiful globes with their glowing carbon filament inside with which

we are all familiar, and with which the names of Swan in this country and Edison in America have been connected. Besides being larger, however, its carbon is also many times thicker than the delicate filament of the Edison-Swan lamp. As may easily be gathered, the Sunbeam lamp is intended to take the place of the arc lamp, and to provide what has hitherto been so difficult with arc lights, viz., lamps of varying power to suit varying conditions, without the necessity of adding complicated apparatus. It has also the further advantages that, while the light given is absolutely steady, the lamp itself requires no attention, except when required to be renewed, and that it may be worked upon any existing electric light circuit; so that it will now be practicable to have lights of any required candle-power from 8 to 1,500 worked from one set of electric light plant, and each lamp, of whatever power, more easily controlled than even gas is at present. The Sunbeam lamp is particularly adapted for lighting coaling screens, colliery sidings, docks, ships' decks when loading, fitting shops, the halls and grounds of private mansions, hotels, &c., and many other large spaces, the perfect divisibility of the light making it available in places where hitherto neither the arc nor the small incandescent lamps were suitable. The Sunbeam lamps were employed in illuminating a large portion of the recent exhibition at Newcastle-upon-Tyne, and were awarded a silver medal, which was the only award obtained for incandescent lamps."

Atmospheric Electricity.—In a note presented to the Academy of Sciences of Naples, and entitled "Conditions which are necessary in order to obtain electrical manifestations by the spontaneous evaporation of water, and by the condensation of water, contained in the surrounding atmosphere, though an artificial lowering of the temperature," Prof. Palmieri, in spite of the negative results obtained by Kalischer and others, insists upon the conclusion that a negative charge of electricity is produced by the evaporation and a positive charge by the condensation of water. He observes, however, that the evaporation and condensation must occur with a certain degree of rapidity in order to develop a perceptible electrical effect. Thus, for example, if an experiment be so arranged that a gram of water on a comparatively restricted surface is converted into vapour within 10 seconds, a very appreciable electrical effect is produced in an electroscope without the use of a condenser; whereas if the gram of water requires a minute for its conversion into vapour the production of negative electricity can be observed only by the use of the condenser. Further, if the same weight of water takes an hour to evaporate, it is no longer possible to observe any electrical effect. The fact is the same in the case of the positive electricity developed by the condensation of vapour in consequence of a reduction of temperature. In the daily electrometric observations, made either when the sky is clear or cloudy, the electrometer indication does not exceed 40deg.; it reaches 60deg. on the sudden production of dense fog; whilst on the occurrence of rain, even at a considerable distance from the locality of observation, the deflection is beyond the calibrated portion of the scale, and corresponds to some thousands of degrees. These high potentials are simultaneous with the production of rain, are maintained whilst it continues, and cease when the rain ceases. In reply to those who maintain that the slight electric currents produced by evaporation and condensation are insufficient to account for the tremendous effects of atmospheric electricity, Prof. Palmieri points out that in the case of abundant rain, not accompanying storms, a fall of 1 millimetre of water per minute is of quite ordinary occurrence, *i.e.*, 1 kilo. per sq. metre, or a million of kilos. per sq. kilometre, and that this would correspond to a condensation, on the platinum plate used in his observations, of 6 grams per minute, instead of half a gram, which is all that can be obtained by an artificial lowering of temperature.

Telegraphy in France.—The statistics of the French Posts and Telegraph Department at the present time, as compared with those of a quarter of a century ago, show that very satisfactory progress has been, and is being, made. A comparison between the receipts accruing to the Treasury in 1860 and in 1886 amply proves this. In 1860 the posts and telegraphs brought into the Treasury in France and Algeria a gross total of 69,356,471f., with an expenditure of 51,349,932f., showing a net profit to the Treasury of 18,006,539f. In 1886 the receipts amounted to 172,945,928f., against an expenditure of 139,573,002f., representing an excess of receipts of 33,372,906f. The expenses of administration of the posts and telegraphs in 1886 are divided as follows:—Central administration, 2,062,940f.; working expenses in France 102,058,841f., and in Algeria 3,730,334f.; subventions in France 25,891,013f., in Algeria 879,999f.; reimbursements and restitutions, 4,949,890f. The general totals received for letters and telegrams in 1886 show that there has been an increase of 7,455,874f. over the Budget Estimates, as well as an increase of 2,448,297f. over the receipts for the year 1885; and for Algeria an increase of 274,853f. over the Budget Estimates, and an increase of 6,790f. over the receipts of 1885. These satisfactory results must be attributed to the constant development in the sending of letters and telegrams by the public, and to the more extended use of registered letters. The number of letters carried by the Post Office, including book-parcels, &c., was 1,492,696,573. The total number of money orders issued was 21,499,029, representing a sum of 669,838,286f.; the total number of postal orders was 706,514, which reached a total of 6,873,823f. In Algeria 530,115 money orders were issued for 30,553,950f., and 5,958 postal orders for 56,095f. The total number of telegrams of every class sent by the department was 27,073,198. In 1860 the number of letters carried was 444,489,983, and the number of telegrams 924,993. It will be seen that marked progress has been accomplished in a quarter of a century, and that the postal circulation, and, more particularly, the telegraphic circulation have grown enormously during the last twenty-five years. The number of subscribers to the State telephones, which were 1,082 in 1885, has increased to 1,569 in 1886, an increase of 487 subscribers. The number of conversations held at the public telephonic cabinets, which were 94,441 in 1885, increased to 140,553 in 1886, an increase of 46,112. The Seine is largely responsible for the increase in the postal and telegraphic circulation of France. In 1886 the department which contains the capital, the centre of French intellectual, financial, and commercial activity, furnished to the Post Office receipts amounting to 42,471,436f., and to the telegraphic department 13,412,328f. The total product of the posts and telegraphs for the whole of France having been in 1886 169,446,874f., it will be seen that the department of the Seine has contributed no less than 55,883,764f., or nearly a third of the entire total. The French newspapers profess to regard these figures as being eminently satisfactory in every respect.

CONSTANT PRESSURE IN ELECTRIC TOWN MAINS.

II

In our last article on this subject we have considered the case of a single street with the generating station at one end, and have shown how by the employment of two feeders the total quantity of copper required for the underground conductor can be reduced to very little more than one-quarter of what would be required if the main were directly connected to the station. But so simple a case would hardly ever occur in practice, and, as a general rule, there will be not only one street alone, but a number of streets in which mains will have to be laid. If the streets radiate more or less from one centre, say the market place, and if it were possible to find in or near this centre room for the station, then each street would have to be served in the way shown in our last article by some feeders and a main, and the supply would be, so to speak, from the centre outwards. As a general rule, however, the land in the centre of a town is far too valuable to admit of its use as a site for the generating station, and this must, therefore, be placed at some distance from the best or most densely lighted portion of the town. It will also be only in exceptional cases that all the streets to be lighted radiate from one point. Generally speaking, there will be streets crossing each other in a more or less irregular manner, all of which require lighting. We thus get a network of mains with many crossing points, and it becomes difficult and often impossible to pre-determine for any given distribution of lights the direction and magnitude of the currents flowing through the different sections of the network. In the case of a single main running along a street, we have shown how copper could be saved by placing the lamps of higher voltage nearer, and those of lower voltage further, from the feeding centres. This arrangement was, however, only possible because we assumed the demand for current to be uniform throughout the length of the street, and knew, therefore, beforehand the direction of current in each part of the main. But even in the case of a single continuous main supplied by two or more feeders, the demand for current per yard run need not necessarily be a constant, and, therefore, the direction of current in any part may vary. To fix ideas, let our 400 yard main of the previous article be marked out into four sections, each 100 yards long, and call the ends A, E, and the three intermediate points B, C, and D. The feeding centres are at the points B and D, and when the full supply is on over the whole street, the current delivered at B will flow towards A on the one hand and towards C on the other hand, whilst that delivered at D will flow towards C on the one hand and towards E on the other hand. To adapt the lamps to the corresponding variations of pressure we would, therefore, place those of lowest voltage on the points A, C, E, and those of highest voltage on the points B and D. As long as the lighting varies uniformly throughout the street, this arrangement will be quite satisfactory; but see what happens if, for instance, all the houses between D and E take the full supply, and the rest of the street, with the exception of one house at A and another at C, takes no current at all. The lamps in these two houses are of 98·5 volts, and the permissible pressure must, for reasons already explained, not exceed 100 volts. Since hardly any pressure will be lost in the main between D and A (assuming that only a few lamps are alight in A and C), the pressure kept at D, in order to satisfy these two householders, must be 100 volts. On the other hand, the loss of pressure on the section D, E, where the full supply is on, amounts to 6 volts; and in order to satisfy the householder at E, we must keep 103 volts at D. We are thus forced either to overstrain the lamps at A and C by $4\frac{1}{2}$ volts, or supply $4\frac{1}{2}$ volts too little pressure to the lamps at E. Neither is admissible, and it will thus be seen that the expedient of using lamps of different voltage becomes impracticable as soon as the conditions of supply cease to be uniform. Another objection to the use of different voltage lamps is the complication which would thereby be introduced in the administration. The necessity to give every subscriber a different lamp would entail too much labour and lead to frequent mistakes.

The only plan for practically working the installati therefore to employ the same voltage lamps througl and limit the rise and fall of pressure in the mains t $1\frac{1}{2}$ volts, as already explained. To satisfy the househ at E we would therefore keep $101\frac{1}{2}$ volts at the fee centre D, and this would only overstrain the lamp A and C by $1\frac{1}{2}$ volts. The reasoning we have here ap to the case of a single main is obviously also applicab that of a complete network. Accordingly as the der for light shifts from one group of houses to another g so will the strength and direction of the current va each part of the network, and any arrangement of l which depends on the fall of pressure in one parti direction becomes impracticable. To make the install a success we must therefore employ the same voltage l throughout; we must keep the pressure at the fee centres constant at, say, 101·5 volts for 100 volt la and we must lay down a network of mains of such that the pressure in any point and at any time not fall below 98·5 volts. To make certain of condition we imagine all the mains of the network about midway between one particular feeding centre the surrounding feeding centres. The portion of the work thus isolated will then be supplied by one feeder and the section of cables must be such that at the p where they have been cut the loss of pressure does exceed 3 volts. By choosing a sufficient numbe feeding centres, the portions of the network which we imagine isolated from the rest will be of very simple s in most cases consisting of a few mains radiating from feeding centre, and the calculation of size is thus easy. After connecting again the severed portion of network, we are sure that the loss cannot be greater 3 volts, but may be slightly less, owing to the tenden the rest of the network to equalise the potential. problem is therefore reduced to the following simple position. Given a certain number of feeders and maximum current in each, what provision must be ma the central station in order to keep the pressure at all feeding centres uniform ?

It will be at once obvious that whatever arrangemer machinery and regulating appliances at the station adopted, they must be such that the pressure on each f where it leaves the station can be independently regul The greater the current flowing out on any particular f the higher must be the pressure on that feeder, the quantities being in the relation to each other as repres by the formula—

$$p = 101{\cdot}5 + c\,r$$

where r is the resistance of the feeder, c the current and p is the pressure, which must be kept at its orig order that the pressure at the far end may be 101·5 But it is not sufficient to know the law according to w the pressure at the origin of each feeder must vary must also be able to ascertain at the station whethe pressure at each feeding centre is actually maintain the standard of 101·5 volts, or, if departed from, in w direction a correction becomes necessary. The direct way to obtain the necessary indication evidently to lay a separate pair of potential or ing wires back from each feeding centre to station, and in some Continental installations vision is made for this purpose during the manufa of the cable, one of the strands being insulated from rest of the core and used as a testing wire after the is laid. Where no testing leads exist, a fairly acc knowledge of the pressure at the far end can be obta from observing the pressure and current at the station To make the calculation it is, of course, necessary to l the resistance of the feeder, which is, to a certain ex dependent upon its temperature, and therefore also the current. But for obvious reasons the variation in perature can only be small, and will therefore not seri disturb the result. The pressure at the feeding centr also be ascertained by means of a differentially wound meter at the station, as will be evident upon consid the formula

$$101{\cdot}5 = p - c\,r.$$

The high resistance coil on the voltmeter, if it were

would indicate the pressure p; the low resistance iich is in series with the feeder but acts in opposition pressure coil, would, if used alone, indicate the . By correctly proportioning the two windings we can re produce an instrument which indicates whether ation between pressure and current, as shown by the ormula, is being maintained, and any deviation of dle from the mark corresponding to 101·5 volts can erved, and the pressure on the feeder suitably d.

iave now narrowed down the general problem to that pendently regulating the pressure at the origin of eder, and this might be done in either of the following –

ach feeder is supplied with current from its own e dynamo, the speed or exciting power of which is d in accordance with the indications of the voltmeter feeder. All the dynamos are virtually coupled in , not immediately at the station, but through their and the network.

ll the dynamos are coupled in parallel at the station rk at 101·5 volts, delivering current to two main om which the feeders branch off. Into each feeder is inserted a small dynamo to raise the potential of tgoing and lower that of the incoming feeder in ance with the external requirements.

ll the dynamos are coupled in parallel by two main the station and work at a potential varying between volts or a little over in the day time, and the um pressure when the full supply is on in the g. All the feeders branch off from the main bars, nection being made by means of rheostats, so that n be balanced against each other.

iese three methods only the last has as yet been used in central station lighting. At first sight it appear as if this method were exceedingly uneco- l because entailing a considerable waste of energy in the rheostats. We shall, however, show that this s not so great as might be supposed. The other two ls are in theory perfect, entailing no waste of energy that which in the feeders is unavoidable, but in e there are serious objections to both. Let us first r the method of installing a separate dynamo ach feeder. We have already shown that to economy in copper it is necessary to use a large r of feeders, and therefore we would have to instal a umber of dynamos also, most of them of medium or ize. This not only makes the generating plant more ive, but also complicates the working of it, and es the liability of failure in the same proportion as mber of separate machines is increased. Another ck of the system is that either the machines must nequal size, or else some of them must be too large r work at all times. But the greatest objection lies expense and difficulty of providing reserve machines. sly a large number of such machines will have to be d, and very complicated arrangements will be re- for effecting the substitution of a reserve machine incapacitated whilst running. In fact, whilst a breakdown of one machine out of a number which rking in parallel would hardly be noticed out- e station, a similar breakdown of a separate e must perceptibly lower the pressure on that part network which is in the neighbourhood of its feed- tre. Another and scarcely less important objection the majority of the machines must be kept running nd day. Although the machines may scarcely be ny work in the daytime, yet we must keep them in so as to retain the standard pressure on all the centres throughout the network.

egards the second plan, the objections to it are of a t nature, but of equal importance. It is true that to the parallel coupling of the main dynamos larger es and a smaller number of them can be used, and a breakdown of one will only throw a little additional those left running without producing any sensible pressure outside, and that when running light the y of main dynamos can be thrown off; but, on the and the large number of small dynamos, for regulating the pressure on each feeder would introduce great complications and liability to failure. In this connection it must not be forgotten that we want twice as many small dynamos as there are pairs of feeders—in other words, that an armature and commutator must be inserted in series with each branch leading to a feeder, whether this be an outgoing or returning feeder. To make this point clear, let us assume that we insert regulating dynamos only into the outgoing or positive feeders and see what would happen. Consider the case of two feeders, A and B, one passing the full current and losing 20 volts, and the other passing half current and losing 10 volts. The regulating dynamo on the positive branch of A would raise the potential from 101·5 to 121·5 volts, and that on the positive branch of B would raise it to 111·5 volts, assuming the potential of the negative main bar in the station to be zero. Now the loss on feeder A is equally divided between the outgoing and returning lead, and therefore at the feeding centre of A we would have 111·5 volts on the positive main of the network, and 10 volts on what we must call the negative main of the network, though its potential in reference to that of the earth is still positive. Where the feeder B joins the network we would similarly have 106·5 volts and 5 volts. But this is inadmissible. Not only the potential difference between the network mains at each feeding centre must be constant but the absolute potential as well, for were it otherwise we would have strong currents flowing from one feeding centre to the other, and upsetting all our arrangements for equalising the pressure. To avoid this difficulty we must therefore raise the pressure in the positive branch of the feeder by exactly the same amount as we lower it in the negative branch. Thus, in our example, the positive branch of feeder A would at the station be raised to 111·5 volts, giving 101·5 volts at the feeding centre. The negative branch would be lowered to – 10 volts, giving zero at the feeding centre and also at the negative main bar at the station. Similarly on feeder B one branch would be raised to 106·5 volts, and the other lowered to – 5 volts. We require thus for each pair of feeders two dynamos, or at least a dynamo having an armature with two circuits and two commutators. Such an arrangement would evidently be too complicated for practical use, and hence there remains only the slightly wasteful but exceedingly simple method of balancing the feeders by artificial resistances for maintaining the pressure over the whole network constant. With this method we shall deal in our third article.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY B.SC., F.R.S.E.

(*Continued from page 105.*)

The tests which were given in the last part of this article as convenient for use during the construction of an isolated electric light installation are of course equally applicable to the more general case of a system of main and branch leads which are being laid down from a central station for the supply of electric light or electric power, or both. In laying down and extending central station systems each section should be tested and made perfect before it is joined to the mains, and it is important that the whole system should be so arranged that it can afterwards be easily broken up into manageable parts for testing purposes. In all cases where the branch mains, and the various sub-branches forming the network of leads, are supplied with both switches and automatic cut-outs, it is convenient to have the switch in one lead and the automatic cut-out in the other. When this is the case any section can be easily isolated either for repairs or for testing without it being necessary to undo any permanent connection. It should be borne in mind that the tests already indicated are simply to be applied for guidance during construction, and are in no case to be considered sufficient to insure absolute safety; the final tests must be much more searching, especially with reference to insulation from earth and between the different leads. The final

tests for insulation should, if possible, be made with an E.M.F. fully equal to, and it is better to be considerably higher than, the ordinary working E.M.F., and the tests of the material before it is sent to be installed should include a test for the rupturing E.M.F. This last, or rupturing force test, is of considerable importance for material which is to be used for alternate currents, especially where the maximum E.M.F. is high. Before proceeding to consider the final tests to which an installation should be subjected, and the tests which should be applied to the material, it will be convenient to consider somewhat fully the elementary principles of the different methods of testing which are in common use.

Measurement of Resistances.

1. *Wheatstone's Bridge Method.*—This is perhaps the best known and most widely-used method of comparing resistances which has yet been devised, and for a large class of measurements it is extremely convenient. The arrangement is indicated in Fig. 3. Suppose four resistances,

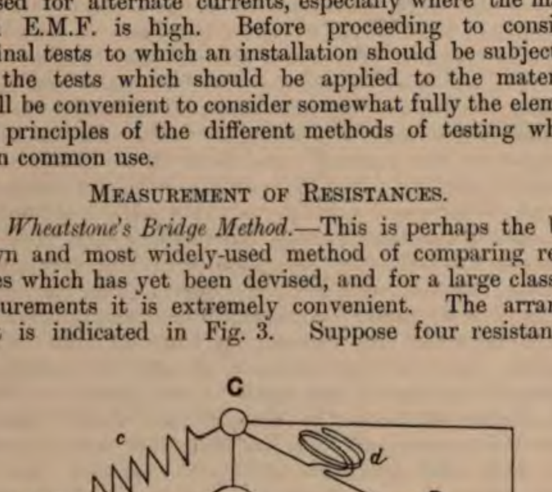


Fig. 3.

a, b, c, d, to be joined at the points, A, B, C, D; one pole of a battery, E, to be connected to, and the other pole through the key, K_2 to B, so as to include the four resistances in its circuit; and the two points, C and D, to be connected through a key, K_1, and the coil of the galvanometer, g. When the key, K_2, is closed two currents flow through the quadrilateral between A and B, a and b forming one circuit, c and d another. It is clear that if the key, K_1, is not closed, and hence no current flows through the galvanometer, the same current must flow through a, as flows through b, and likewise the same current must flow through d as flows through c. Now, by Ohm's law, the current through any part of a circuit is equal to the electromotive force divided by the resistance between the ends of that part. Let then e_1, e_2, e_3, e_4, be the E.M.F. s between A and D, D and B, A and C, and C and B respectively, and we get the following simple equations:—

Current through a equal current through $b = \frac{e_1}{a} = \frac{e_2}{b}$.

Current through c equal current through $d = \frac{e_3}{c} = \frac{e_4}{d}$.

Now, if we further assume that when K_1 is closed no current flows through G, or that there is no E.M.F. between C and D, we have $e_1 = e_3$ and $e_2 = e_4$, and therefore

$$\frac{\frac{e_1}{a}}{\frac{e_3}{c}} = \frac{\frac{e_1}{a}}{\frac{e_1}{c}} = \frac{c}{a} \quad \text{and} \quad \frac{\frac{e_2}{b}}{\frac{e_4}{d}} = \frac{\frac{e_2}{b}}{\frac{e_4}{d}} = \frac{d}{b}$$

but

$$\frac{\frac{e_1}{a}}{\frac{e_3}{c}} = \frac{\frac{e_2}{b}}{\frac{e_4}{d}} \quad \text{and hence} \quad \frac{c}{a} = \frac{d}{b}.$$

We see, then, that if we have four resistances arranged as in the figure, and can adjust one or more of them until, when the key, K_2, is closed, the closing of K_1 gives no deflection on the galvanometer, G, any one of the resistances can be calculated from the known value of one other, and the known ratio of the remaining two. For example, let c be a coil of wire the resistance of which is required, and let d be a resistance which can be conveniently varied, while the ratio of a to b is known, then, when d has been so adjusted that with a current flowing through the circuit no deflection is produced in G by closing the key K_1,

$$c = d\frac{a}{b}.$$

Let, for example, $d = 500$ ohms and a and b both equal 10 ohms, then $c = 500\frac{10}{10} = 500$ ohms. Again, if $d = 500$ as before, but $a = 10$ and $b = 1{,}000$ ohms, then $c = 500\,\frac{10}{1{,}000} = 5$ ohms, and so on.

To facilitate the use of this method of measuring the resistance of conductors, boxes containing sets of coils adjusted with considerable accuracy to ohms and multiples, and submultiples of ohms, are made by most of the leading instrument makers. These vary very greatly in quality and correspondingly in cost. Examples of some of the different forms will be given below, and at the same time the main precautions which must be taken during the manufacture, and the methods of calibrating or adjusting them, will be described. These boxes generally contain, besides the sets of coils used as the adjustible resistance, two other sets of coils to be used in forming the two sides of the bridge indicated by a and b in the above examples. These two sets are usually, but not necessarily, adjusted to even numbers of ohms. They are designed merely to allow a convenient ratio to be given to the two constant resistances and to facilitate calculation the ratios chosen are almost always 1, 10, 100, ... and 1, $\frac{1}{10}$, $\frac{1}{100}$, ... This arrangement is very convenient, and is sufficient for almost all practical purposes, but it does not give the means of taking good advantage of all the sensibility which the method is capable of giving. The following rules should be as nearly as possible attended to while making the tests. Assuming c to be the resistance to be measured, g the resistance of the galvanometer and f that of the battery, then:—

Rule 1. The resistance of the side b opposite to c should be made as nearly as possible equal to the square root of the product of the resistances g and f, that is, b should be as nearly as possible equal to $\sqrt{fg}$; at the same time a should be as nearly as possible equal to

$$\sqrt{\frac{cf(c+g)}{c+f}}.$$

Rule 2. With a battery of any particular type it is always an advantage to add more cells until the resistance of the battery becomes equal to the resistance which is being measured.

Rule 3. With galvanometers of similar type that which has a resistance nearest to the resistance under test is the best.

Rule 4. The greatest sensibility is obtained when all the resistances, a, b, c, d, f, g, are equal.

The last rule must not be taken to mean that it is an advantage to use a high resistance galvanometer and a high resistance battery *per se* when testing high resistances, but should be read along with Rules 2 and 3, when its true meaning will be apparent.

There are practical difficulties which limit the application of these rules, and it may be instructive to consider some of them. In the first place the resistances in the sides a, b, of ordinary boxes of coils are generally 10, 100, 1000, &c., while the resistances in the box itself usually range from a minimum of $\frac{1}{10}$ of an ohm to a maximum of 10,000 ohms. Now consider a case, suppose the resistance of the galvanometer and the battery are each of them 10 ohms resistance, then the value of b is fixed at the $\sqrt{10 \times 10}$ or 10 ohms. Let a resistance of approximately 90 ohms be put for c and we require to make $a = \sqrt{\frac{90 \times 10(100+10)}{100+10}} = 30.$

But a is to b as c is to d, and as a is thus three times b, the resistance to be put in the box is approximately one-third of c or, in this case, 30 ohms. It will be observed that in this case d is equal to a, and this is always the case when $f = g$ and $b = \sqrt{fg}$. The point particularly to be noticed,

however, is that the resistance required in the box is less than that of the conductor under test and hence unless the box contains small resistances it becomes impossible to obtain an exact balance. The resistance required in the box in this method is always less than that under test when the latter is greater than the square root of the product of the battery and galvanometer resistances, and hence it is not always advisable to adhere rigidly to the arrangement for maximum sensibility. In all cases, however, where a resistance equal to $\sqrt{fg}$ can be got with sufficient accuracy in the box the method should be adhered to as closely as possible.

In the case given above, for example, where d was 30 ohms, a box containing resistances down to tenths would have given the resistance to one-third per cent., while the amount of the deflection of the galvanometer to opposite sides when the nearest resistances, too high and too low, were inserted would give the means of estimating much more closely. It may be stated generally that, in accordance with the rules here given, when the resistance to be measured is high, a lower resistance than it is required in the box, and when the resistance to be measured is low, a higher resistance than it is required in the box, and in this respect the method is convenient as well as sensitive. There is, however, a somewhat serious objection to the use of unequal ratios at all in the two sides a, b, arising out of the fact that unequal ratios are seldom so exact as equal ones, and besides very liable to be rendered inexact by unequal heating due to the passage of the testing current. There is still another chance of error in unequal ratios, and that is the probability of unequal change of resistance with change of temperature in the two coils, the wires being as a rule quite different in the two coils and hence the ratio is only accurate at one particular temperature. In well made resistance boxes the risks of error here referred to are minimised, and it is to be hoped means will soon be found of overcoming the difficulty altogether. This subject will be more fully discussed in its appropriate place.

With the regard to the general use of this method, it may be stated that it is capable of giving, when proper sets of standards of the ordinary pattern are provided, very accurate results for resistances of from 1 ohm upwards, but when the resistances are much lower than this some modification is generally advisable. Sir William Thomson, about thirty years ago, made sets of coils so arranged that they could be used either in series or in parallel, and later he made boxes of "conductivities." Lately he has worked out a modification in some important details of his original plan of combined resistances and conductivities, and has named the arrangement, which is cylindrical in shape, a "mho-ohm drum." There is no doubt but that this combination system of conductances and resistances greatly lengthens the range of accurate measurement which can be obtained with one set of standards; but even then it is not advisable, on account of the unavoidable resistance at the terminal contacts, to measure resistances much below $\frac{1}{10}$ of an ohm in this way. Great care must be taken that the wires are clean at the points where they are pinched by the terminal screws, and also that the terminals themselves and the plugs and holes are perfectly clean. When proceeding to measure the resistance of any conductor, assuming the galvanometer and other connections made, first observe the direction of the deflection of the galvanometer either before the conductor is put in, and consequently c is infinite, or after c is joined, and d is made either infinite or very high. This gives the means of telling when nearly enough, or too much, resistance has been inserted in the box, after which the adjustment can be readily made by observing the effect of successive small changes. As to the proper order of closing the circuit, it is usual to lay down the rule that the battery circuit must be closed first, and for a great many cases this is absolutely necessary. In some other cases it is not so convenient. In all cases where the conductor under test has considerable capacity, either electrostatic capacity, like an ordinary telegraph line or submarine cable, or electro-magnetic capacity due to self-induction, such, for example, as the capacity of the armature or field magnets of dynamos, the battery key K_2 must be closed first, and it must be kept closed for a sufficient time to allow steady flow to be set up. It is not unusual to find that in inexperienced hands a dynamo is reported to have no definite resistance at all, while the whole fault lies in the battery circuit being closed for a variable and, in all cases, too short a time before the galvanometer key is closed. In cases where the coils of large magnets are being tested, the battery key may require to be closed for as much as 10 or 15 seconds, or more, before absolutely steady flow is established. When great accuracy is required, and the battery key must be closed first, it is well to use a reversing key in the battery circuit and test with both directions of current, so as to eliminate any thermo-electric effect in the circuit. The presence of thermo-electric disturbance can always be detected by closing the galvanometer key, the battery key remaining open. There should be no deflection under these circumstances. When there is a deflection it may be allowed for by balancing to the same deflection, but it is better to use reverse currents and take the mean of the results. On circuits where there is practically no inductive impedence the galvanometer key may be closed first, and balance made to zero *permanent* deflection. Great care has, however, to be taken that there is no direct action of the current on the galvanometer causing a deflection when the battery key is closed, and also that the battery circuit and key are so well insulated that no current flows through the circuit when the battery key is open. The insulation of the battery circuit and key can be readily tested by varying the resistances in the bridge through a wide range and closing the galvanometer key when, if the insulation is satisfactory, no deflection, or, if there is some thermo-electric effect, no change of deflection should be observed.

(To be continued.)

PARIS UNIVERSAL EXHIBITION, 1889.

The Society of Telegraph Engineers has lost no time in bringing the question of the forthcoming exhibition to the notice of electrical engineers. We understand that a committee of its Council has been formed to consider the best methods by which British electrical science can be represented. A preliminary meeting of intending exhibitors will be held at the offices of the Society, 4, The Sanctuary, at 3 p.m. on Monday next, when, no doubt, the question of ways and means, as well as other important questions, will be settled. It is almost sufficient to prove that no effort will be spared to make this meeting a success, and to give full details of all that has been, is being, or is possibly to be done with regard to the electrical exhibits, when we say that Mr. Aylmer, the hon. sec. of the Society in France, will be present at the meeting. Those whose knowledge of the 1881 Exhibition is hearsay only, can have no conception of the unceasing energy displayed by Mr. Aylmer in connection with the English exhibitors, and we are glad to see him physically able to take an active part in the organisation of the 1889 exhibition. The commissioner to the electrical section of the exhibition is M. Berger, and those who know this gentleman will understand that every facility will be held out to exhibitors to enable them to make a successful display.

It may be stated here that even if there should be another English committee, for general exhibits, the doings of the electrical exhibitors will in no manner be under its control, so that the necessary arrangements for the latter can at once be made. The following information may be of interest to intending exhibitors:—

Electrical instruments, machinery, and apparatus generally may be sent, either as ordinary exhibits, or as forming part of the arc light plant required for the illumination of the exhibition. No charge will be made for space, but the exhibitors will be called upon to pay their proportion of the general expenses of decoration, supervision, &c. Motive power, in the shape of belts, steam, water, or gas, will be supplied free of charge to exhibitors taking no part in the lighting. Exhibitors taking part in the lighting of the exhibition will be supplied with motive power at a moderate fixed sum, and in return will receive a share of the extra admission money paid by visitors entering during the

evening, in proportion to the amount of power rented by each exhibitor. The Director-General of the Executive Committee has given the assurance that the arrangements necessary for the convenience of British electrical exhibitors will be arranged entirely with the Society, which will act as their representative.

With regard to the total power required for lighting purposes, it is estimated at 3,000 h.p. The necessary motive power will be installed by a syndicate intrusted with the carrying out of the lighting. Out of the total power, M. Berger has reserved to the English section, for the use of intending contractors for electric lighting, 500 h.p., at a charge of £40 per 10 h.p.—which is the minimum supplied—for the whole time the Exhibition is open. The admission to the Exhibition during the day time will be 1fr., and during the evening, when the electric light is on, 2fr., the additional franc being equally divided between the general administration of the Exhibition and the electric lighting syndicate. The working expenses of the syndicate will be paid out of the £4 per horse-power received from the lighting contractors, and out of the extra admission money; and if any profit be left it will be divided at the close of the Exhibition among the contractors who will have to bear the cost of their own installations and their maintenance.

Already a number of the best known firms have signified their intention of exhibiting, and as regards the 500 h.-p. reserved for lighting, we should suggest immediate application, as here again firms have offered to take the whole. The power should be sufficient to permit every firm of repute to show the merits of their machines and lamps.

ON THE POSITION AND PROSPECTS OF ELECTRICITY AS APPLIED TO ENGINEERING.*

BY MR. WILLIAM GEIPEL, OF EDINBURGH.

(*Continued from page 115.*)

Another interesting example of pumping is afforded by the recent introduction of electricity for this purpose into St. John's colliery, Normanton, where 39 gallons per minute are raised 530ft., equivalent to 6·3 h.-p. of work done. An old girder-beam engine is utilised to drive the dynamo, and indicates 14·2 h.-p. with full load. The efficiency throughout is therefore 44·4 per cent. The power lost in the different stages is as follows :—

	h.-p.	per cent.
Engine and dynamo running light	1·7	12·0
Conductors	0·88	6·2
Motor and first shaft	2·8	19·7
Driving pump empty	2·0	14·1
Other losses	0·52	3·6
Total loss	7·9	55·6
Useful work	6·3	44·4
	14·2	100·0

It will be seen that only a small part of the loss takes place in the electrical plant, the greater part occurring in the pump, engine, and gear. The pump is driven by toothed wheels, which are worked from the motor by a cotton belt, in order to obviate transmitting the vibrations of the pump back to the motor. This plant is being extended to pump in addition 120 gallons per minute against a head of 900ft.

At Thallern colliery, on the Danube, where electricity has replaced steam for pumping, it has been found after several months' work that a considerable saving in coal is effected; also that the temperature of the pit is reduced some 14deg. Fahr., steam having previously rendered the atmosphere of the mine unbearable.

In the mines of Blanzy, in France, a ventilating fan is driven from a generator at bank. The fan is 150 yards in, 2½ft. in diameter by 11¾in. broad, and runs at 730 revolutions per minute. The temperature at the face has been reduced 15deg., from 95deg. to 80deg. Fahr., since its introduction.

Shipyards.—In shipyards and similar works electricity has already proved itself a suitable and economical means of transmitting power for riveting, drilling, &c. The electro-magnetic tools described in Mr. Rowan's paper at last year's Summer Meeting (*Proceedings* 1877, page 323) are being successfully employed in yards at Dumbarton. This system possesses the additional advantage that the tool can be firmly held to its work by magnetic attraction alone, without the use of bolts, so that no holes need be left for hand-riveting as is required with other machine-riveters.

Transmission to great distances.—The transmission of power to great distances is not of such vast importance here as in the colonies, although even in the small sluggish rivers of this country there are large amounts of power running to waste. In many places where works have been erected for utilising water-power it has been at the sacrifice of convenience of situation, or of a ready and cheap means of receiving and despatching goods; whereas by means of electricity the same water-power might have been transmitted to a locality more suitable for the works. For short distances it does not pay to transmit water-power by electricity, owing, as previously mentioned, to the cost of dynamos; in such cases transmission by shafting or wire ropes is cheaper. But for long distances shafting is out of the question, wire ropes become more expensive, and electricity is cheapest. In Table I. is shown the first cost of plant per horse-power transmitted through different distances by electricity, water, air, and wire rope. There is, of course, a limit beyond which it would not pay to transmit power, because with the distance the capital outlay increases, until the interest thereon outweighs the cost of the coal which would be consumed by a steam engine on the spot. Wire rope is, perhaps, cheaper for distances of less than one mile, although the disadvantages of having to lubricate pulleys and to provide substantial supports would in many cases compensate for the higher cost of electricity. The limit of distance to which it is economical to transmit water-power increases with the amount of power transmitted. From Table II., showing the cost of 1 h.-p. per hour,* it appears that, when the power is generated by a fall of water, 5 h.-p. can be transmitted 11,000 yards at the rate of 0·52 penny per h.-p. per hour by electricity, while at the same rate also 100 h.-p. can be transmitted 22,000 yards—that is, double the distance. The transmission of steam power over long distances is seen from the same table to be not economical; small power, say up to 10 h.-p., may be transmitted as far as three miles; but larger powers not so far, because for larger power a local engine becomes more economical.

TABLE I.—*First Cost of Plant per Horse-power transmitted.*

Total Power Transmitted	System of Transmission.	Distance of Transmission in Yards. 110	1,100	11,000	22,000
H.P.		£	£	£	£
5	Electric	75	81	142	210
	Hydraulic	41	97	610	1,280
	Pneumatic	73	210	1,090	2,060
	Wire-Rope	6·5	61	760	1,220
100	Electric	32	35	59	87
	Hydraulic	14	28	164	310
	Pneumatic	26	34	109	192
	Wire-Rope	1·1	8·4	81	162

As an interesting instance of the transmission of power by electricity over long distances, that at the Phœnix Gold Mines in New Zealand may be referred to. The current is generated by two No. 8 Brush machines, each capable of giving 20,000 watts or 26 h.-p.; they are driven by Pelton water-wheels, with a head of 180 feet. The current is conveyed to the motor, about three miles distant, and back again, by a No. 8 B.W.G. copper wire (0·165in. thick)

* A paper read before the Institution of Mechanical Engineers, February 2, 1888.

* This is a modification of a table given in Mr. Kapp's work on "Electric Transmission of Energy." The original table is based on the investigations of Herr Beringer and on the cost of power as determined by Prof. Grove.

TABLE II.—*Cost per Horse-power transmitted per Hour.*

Total Power Transmitted.	System of Transmission.	Power Generated by a Steam Engine. Distance of Transmission in Yards.				Power Generated by a Fall of Water. Distance of Transmission in Yards.			
		110	1,100	11,000	22,000	110	1,100	11,000	22,000
H.P.		Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.
5	Electric	2·25	2·41	3·29	5·20	0·35	0·37	0·52	0·84
	Hydraulic	2·50	3·15	10·50	19·00	0·29	0·48	2·48	4·79
	Pneumatic	2·70	3·30	9·53	16·70	0·40	0·58	2·40	4·45
	Wire-Rope	1·13	1·88	10·40	22·70	0·11	0·30	2·50	4·86
100	Electric	1·79	1·91	2·63	4·08	0·20	0·23	0·32	0·50
	Hydraulic	1·62	1·78	4·15	6·84	0·16	0·19	0·72	1·14
	Pneumatic	2·00	2·09	3·10	4·50	0·22	0·24	0·48	0·33
	Wire-Rope	1·07	1·22	8·83	9·73	0,08	0·11	0·48	1·19

nearly six miles long, supported on telegraph poles. The power lost in the line is only 3 h.-p. A Victoria motor is used, running at about 350 revolutions per minute; and the power is transmitted to the machinery by a belt.

Deprez succeeded in demonstrating practically that 52 h.-p. could be transmitted over a distance of 35 miles, namely from Creil to Paris, through a copper cable equal in section to a wire of less than 0·2in. diameter. But his machines were not efficient, the power required to drive the dynamo being 116 h.-p., of which 44 per cent. was lost in the dynamo and motor, and 11 per cent. in the 70 miles of the outward and return wire. There is no reason, however, why much more efficient results should not have been obtained; as much as 18 per cent. of the total power was absorbed for maintaining the magnetism of the field of the dynamo, whereas in a well-designed machine less than 5 per cent. should suffice.

Mr. C. E. H. Brown, of Oerlikon, has succeeded in transmitting by electricity 50 h.-p. from water power at Kriegstetten over a distance of 5 miles to Solothurn in Switzerland, with a commercial return of over 70 per cent. Two series-dynamos and two series-motors are arranged on the three-wire system. Each of the three wires is ¼in. diameter, consisting of bare copper suspended on poles about 40 yards apart, with fluid insulators for ensuring good insulation. For a span of 130 yards across the River Aare, silicium-bronze wire is used, which has the same conductivity as copper and a tensile strength of 30 tons per square inch. The current used is 15 amperes, and the potential difference at the terminals of each dynamo is 1,250 volts. The resistance of the line is 10 ohms, and the loss in it is a little over 3 h.-p., or 6 per cent. of the total power. The loss in dynamos and motors is 24 per cent., being much less than in Deprez's machines where it was 44 per cent.

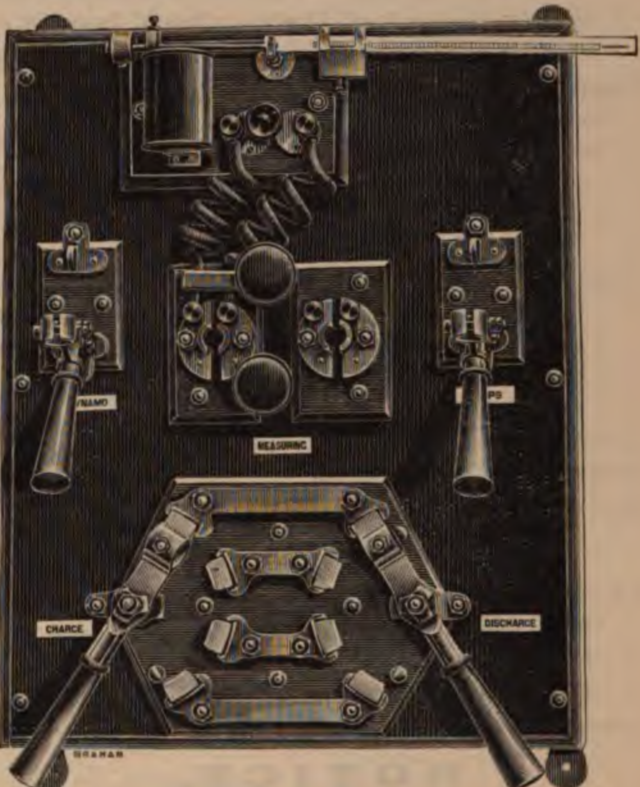
At Hatfield, on the Marquis of Salisbury's estate, the River Lea is utilised to generate electricity, which is transmitted to the house and over the estate for a variety of purposes. Two turbines are used: one to drive a 40 h.-p. Siemens alternating-current dynamo, for lighting the house; and the other to drive a 16 h.-p. Brush machine, for arc-lighting at night, and in the day for working the motors at the house and on the farm. Those at the house drive pumping and ice-making machinery, and a 24in. Blackman air-propeller fixed in the roof for ventilating; on the farm the motors are used for elevating hay and corn sheaves to the tops of the stacks, for thrashing, for cutting rough grass with a chaff-cutting machine for ensilage, in fields extending to a distance of two miles, for grinding corn, &c., to make fodder, and for other purposes. The motors have also been used for pile driving, for making cofferdams where necessary in the river; and also for dredging the river and clearing it of weeds. A Gramme motor, capable of raising 2,500 to 3,000 gallons per hour, pumps the town sewage into a tank at a height of 30ft. for irrigation. The conductors are carried overhead on poles about the farm, and underground in wooden troughs to the house.

In favourable districts the supply of power to farmers by means of electricity is a subject well worthy the consideration of capitalists. If water power is not to be obtained as the prime mover, then steam power must be used as is now the custom, but in a more economical form than in a portable or traction engine. The expense of taking these engines about the farm, both in coal and wages, must render them costly to the farmer in respect of the power actually used. An economical engine could be fixed, for generating an electric current to be transmitted through overhead conductors carried on poles along the roadside.

(To be continued.)

DRAKE AND GORHAM'S SWITCHBOARD.

Messrs. Drake and Gorham have designed the Standard Switchboard, herewith illustrated, for use in accumulator installations, though they can be modified to suit each installation.



Drake and Gorham's Standard Switchboard.

The switchboards are fitted throughout with Drake and Gorham's patent ring contact switches and steel yard measuring instruments, mounted on slate or polished and well-seasoned teak boards.

The arrangement includes regulator switches for both "charging" and "discharging" accumulator circuits, also switches for lamp and dynamo circuits, provision being made for measuring the current in both circuits. For the convenience of contractors, all switchboards are supplied with the connections to the different switches permanently made at the back of the board; it is thus only necessary to solder the cables from the dynamo, accumulators, and lamps, into their respective sockets.

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we issued with our last number a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

SOME PLAIN SPEAKING.

Shareholders in tramway property are concerned in all that relates to the prosperity of such property, and at recent meetings they have been told again and again that chairmen and directors are always on the look-out for success in the way of electric traction. It is our province to frequently read the reports of meetings, and it is simply astonishing to find how a few promises, with a five per cent. dividend, satisfies the ordinary shareholders. We admit five per cent. to be a fair and a moderately safe return to look for, and probably the wisdom of the serpent teaches that a higher dividend brings keener competition. It is better at times in the interests of the directorate not to earn a greater dividend. Only by such reasoning as this can one understand why horse traction continues the ideal traction, so far as directors are concerned, for tramways. They are quite willing to take up electric or rope or any any other system that can be proved to their satisfaction to be successful. That seems at first sight a fair position to take up, but on further consideration we are inclined to think it shows the worldly wisdom of the directors. Plainly, they do not want electricity, or cables or anything else to interfere with their present system; or if anything is to interfere they must somehow or other have a finger in the pie.

We do not wish to boast of what electricians can do or cannot do even in these early days of electrical engineering, but we do know that half-a-score of firms would successfully undertake the driving of ordinary tramcars electrically. There is nothing very startling in the task—certainly nothing to frighten the ordinary engineer. We are promised experiments upon the Metropolitan Railway—to propel trains—real trains electrically. Now that promise does somehow or other take our breath away. It is a big thing, as our cousins across the Atlantic would say; and although we do not despair of its being successful we certainly should not like to prophecy. Whatever be the result—if the promoters will only let their every arrangement be known, it will be fruitful of lessons. Possibly the general public—ourselves among the number—may have misunderstood the extent of these experiments. At any rate we will wish them success.

But, to return to tramcar traction. Why, if it is comparatively easy, has it not been adopted as extensively here as in America? History tells us that during the electric light boom promoters and patentees managed to thrive at the expense of the credulous. Our firm conviction is that gentlemen of this kind desire also to fatten upon what pickings they can get in introducing electric traction upon tramways. Farseeing individuals want to get a patent—with something in it to foist upon a confiding public—to the tune of tens of thousands. The directors of tramcars do not see their way to make a change unless they have a good reason for so doing—and the very best reason is £. s. d. It is not many years since iron rails were used upon all railways—then

steel rails were rolled, but we have yet to learn that the railway companies asked some one else to go to the expense of laying down such rails and proving their success. There were the rails; and the companies laid down a few, tested them, found them good, laid down more still with success, till "steel" has replaced, or is fast replacing, iron. Where is the tramway company who will go to Elwell-Parker, Holroyd Smith, Magnus Volk, and give a definite order for a section of a tramway to be worked electrically, testing it fairly under their own directions? It is asking us to believe too much if directors go on month after month saying we are watching and waiting and hoping for this or that to happen. We do not think there is or can be anything very patentable about tramway design for the promoter to gain his ends; and the sooner this fact is brought home to the minds of directors the better. It is customary now to run to the Patent Office with every idea. The alteration in the pitch of a screw is sufficient to make a patent now-a-days, so is the grand idea of a round instead of a square brush to take off electricity. Really it seems as if Carlyle was right that the world is made up of wise men and fools, but mostly fools, or business would proceed more on the old-fashioned lines of going to a firm in the trade and stating what was wanted. Designs *ad libitum* would be forthcoming if the want was an electric tramway, and a competent engineer would have little difficulty in selecting a suitable one. As we say, when the desire is really to do the work the difficulties which now seem insurmountable will vanish like the mist before the face of the noonday sun; but while the idea is for somebody to make money by patents the obstacles will remain. At present we are told that the Electrical Engineer cannot devise a means to make a good yet safe contact, keep it free from dirt or water, and restrain the leakage to a minimum. It is graciously acknowledged that motors of, say, from two to ten horse-power can be made —that dynamos have arrived at a state of perfection leaving but a small margin for further improvement electrically or mechanically—yet we are told we cannot convey a current safely and economically over a distance of from two to six miles to and from the motor. Our opinion is that the time has come when the technical journals should firmly and respectfully combat these erroneous notions. Not only can we make the motors and dynamos, but we can design a complete system which would suffice for all the requirements of ordinary tramways. Just as we should not for a moment pretend to advocate an ordinary railway to the top of Snowdon, or Mont Blanc, or Mount Everest, so we do not advocate the use of electric traction indiscriminately. There are times and places where horses, cables, steam or other methods of traction are best. Our desire is to state, as emphatically as can be stated, that there exists no reason why fussy experiments should be made, or patents considered, or promotion money paid to introduce electric traction upon ordinary tramway lines. Dealing in "notions" is becoming almost as extensive in England as it is in America, and the good old plan of calling in an eminent engineer—a specialist in his own branch—to advise is not followed, at any rate so far as the electrical branches of engineering are concerned, because it is old-fashioned. We do not yet go to the men with "notions" to design our railway bridges or even our steam engines. We go to the men who have had a thorough training in the branch, and are acknowledged masters by their colleagues. The Institution of Civil Engineers has done much to remedy "quackery" in certain branches of engineering. Will the Institution of Electrical Engineers do as much for electrical engineering? If so, we may hope ere long to see promoters checkmated and their nostrums relegated to the backwoods, when work will be carried out in a proper manner, and progress will not be delayed because of a desire to gather in much money from a deluded public.

HIGHER CABLE RATES.

The whole tendency of the Anglo-American meeting, reported in another column, was to sing the tune of "saxpence will not pay." A fighting tariff has been tried and failed. The Commercial Company has held its own and will be the victor. This result might have been forseen, but we must confess to having believed in the reality of the fight, and the determination once for all to put down competition across the Atlantic. As it is, the directors have pretended to fight

"With cautious step and prospect wary,"

while all the time intending to give in at a convenient season. From what we can see now, the arrangement between the rival companies might just as well have been made before the shareholders lost any of their dividends as after. The sixpenny tariff will not pay—that is the cry. It was made for a fighting tariff; but the shareholders will begin to ask where the benefit of the fight comes in? Was it not ever thus in the history of Atlantic telegraphy? Have not the directors blustered and sworn that they would fight to the death, but always in the end arranged to shake hands and contribute to a pool? The poor shareholder has had to pay the piper, though he could not call the tune. There are more cables in the Atlantic than are required. The business to be done is insufficient to fill the cables, or to pay a satisfactory dividend at this tariff, say the directors. It may be so, yet a closer inquiry into the question would show that, though not paying a satisfactory dividend, the low tariff ought to pay a better dividend than it has done. According to the chairman, the tariff was reduced from 2s. to 6d., and the messages have at the rate increased over one hundred and sixty per cent. The next question to be answered is the increase in cost to send this increase in messages. The increase should be comparatively small. Nothing is increased so far as the cable or electrical apparatus is concerned. The clerical staff, and the clerical staff only, should show increase of

expenditure. The odd ten or twelve per cent. will, we fancy, account for all necessary increase, leaving 150 per cent. to go to the ordinary fund. This is somewhat, though perhaps not exactly, the same as a tariff at 1s. 3d. on the old lines. Of course our line of argument may be altogether fallacious, but really from this reasoning it seems as if the dividend is not what it ought to be, that the fight is ended just when the public is putting the company into almost its old position by increase of patronage. It may pay directors to say that the public has benefitted by this attempt at cheap telegraphy; so it has, but the directors care as much for the public as we do for the gnomes and fairies of children's tales. The raising of the tariff will not recoup the shareholders their loss. If, on the other hand, the fight had been real and a victory won, the shareholders would have been fully recompensed for the loss sustained. The Commercial Company would not in so short a time have put itself upon a level footing with the older companies as it has done, had they been contented with accepting the 1s. 8d. rate in lieu of the 2s. rate. Now the probability is that the whole of the Atlantic cables will form a pool and share *pro rata* according to capital. The 'cute Yankee has indeed been fortunate this time. Anglos will perhaps rise a point or two, and those who have loaded heavily during the time of the so-called fight will rejoice at the turn affairs have taken. The puzzle is to know who are the fortunate ones.

NOTES ON THE ELECTRIC LIGHT IN SOME CONTINENTAL CITIES.

BY. B. H. COLLINS, OF THE LIVERPOOL ELECTRIC SUPPLY CO.

Paris.—In the neighbourhood of the Louvre, and in the Place de la Concorde, Jablochkoff electric lamps are used, suspended from pillars, some 20ft., others 60ft. high. Of the many installations in Paris that of the new theatre, the Nouvel Opera, forms a great attraction, the building being most sumptuously fitted up in every respect.

Lucerne.—The Schweizerhof Hotel, of large dimensions, near the quay-side, is fitted throughout with electric light, both arc and incandescent lamps being employed. The fittings used are substantial in appearance and tasteful in design. Arc lamps are placed outside to illuminate the gardens in front, and also afford light to a good orchestral band which possesses a stand near the hotel. The current for this hotel and several other buildings is supplied from the works of Gebruder, Troller, and Co., at Dorenburg. At Lucerne there is a small private generating station which supplies a hotel near the lake with current for 250 incandescent lamps. The dynamo employed here is one manufactured by R. Aliott and Co., Suisse "Helvetia" type, and gives 150 amperes and 120 volts at 850 revolutions. It is fixed on a stone bed with sliding gear for tightening, and is driven by a semi-portable engine and boiler made by Gebruder Sulzer, Winterbur. One man has the entire charge of the plant, and appears to keep everything in proper working order. There is a voltmeter and ammeter made by R. Aliott and Co., mounted on a board on the wall, for testing.

Como.—The electric light has recently been introduced for the first time in this beautifully-situated city. This preliminary installation consists of five arc lamps, fixed on poles 30ft. high, in the Giardino Publico, or public gardens, four of them being placed outside a "Podiglione Excelsior," or cafe, and the fifth lamp being situated near the main road fifty yards off. Close to the main road the engine shed is situated. The dynamo used here is of the Bürgin type, manufactured by Altorf Bros., of Bâle, and is fixed on a stone bed 1ft. 6in. high. A semi-portable engine and boiler (local make) provides the motive-power. There is an ammeter (indicating eight amperes when lamps are at work) and a small frame with resistance coils fixed on one side of the engine room. One man is employed to look after the plant, and the light is remarkably steady. Outside this cafe numerous small round tables are placed, and a temporary stage in the open air is also provided for concerts, &c., the electric light shedding its radiancy over all. Doubtless further additions will shortly be made in Como, now that the light has obtained its preliminary footing.

Milan.—Electric lighting here is general throughout the greater portion of the City, both as regards arc as well as incandescent lighting. The mains are all underground. In the principal buildings, fittings of the most elaborate description are used, while in the less important houses plain iron pipe fittings are fixed. The large central generating station of the Edison Company which supplies the current, is situated in the basement of an oblong building about 120ft. long by 35ft. broad, in a narrow street not far from the cathedral. Eight old-type Edison machines about 7ft. and 6ft. high, giving 800 amperes and 110 volts at 350 revolutions, and driven direct by engines of Armington and Sims type, are placed in a row down nearly the whole length of the basement, with an interval of a few feet between each. On one side there are four Thomson-Houston dynamo machines used for the arc lighting, the incandescent lamps being supplied with current from the Edison machines. The mains leave the premises from both ends of the building. Some of the arc lamps in the streets are arranged on iron pillars about 30ft. high, whilst others are hung from an iron chain stretched across the street. Near one end of the chain there is a short iron rod screwed into an iron ring, which tightens or loosens the chain as desired. In the justly renowned marble *cathedral* the electric light is used, but the usual candles still predominate at the High Altar. At the Scala Theatre upwards of 4,000 electric lamps are employed in the various rooms and body of the building. One massive gilt metal electrolier fixed in the centre of the theatre contains 400 lamps. In the principal promenading room there are three electroliers with 108 lamps in each, and other rooms possess fittings with lamps varying in number, viz., 32, 20, and 7 each. There are six tiers or galleries to this theatre, and looking from the pit, 300 lamps can be seen distributed, in 60 brakets of 5 lamps each, round the sides —10 brackets for each tier or gallery. The switchboard arrangements are on the right-hand side of the orchestra. There are other controlling switches situated in the basement. The wires used throughout the building are covered with an insulation of asbetos.

Turin.—At Turin there are three small generating stations for electric light—viz., The Via Librario, Piazza Castello, and the Instituto Tecnico. Over 500 h.-p., is used in Turin for electric lighting. The ground is of a dry gravelly nature and particularly suitable for underground mains, which are placed about 2ft. deep and 5ft. from the sides of the streets. The Edison system of mains is used in several parts of the city. Near and in the railway station, Siemens arc lamps are employed, and also at the Piazza Milano and Piazza Castello. Four iron pillars about 50ft. high are erected in each of these squares. They are substantially constructed, and neat in design. At the foot of each lamp there is a testing box covered with an iron plate. In the neighbouring arcades "Cruto" incandescent lamps, protected by well-glasses, are attached to plain metal pipe pendants, the lamps being about 9ft, above the ground. In the Via Garibaldi, 50 Thomson-Houston lamps are employed to illuminate the street, and are suspended from curved brackets fixed in the walls about 20ft. above the ground level. The bottom half of the lamp globes is frosted to prevent a dazzling effect. Other streets in the neighbourhood are lighted with from 20 to 30 lamps placed at distances of about 30 yards apart. The electric light is gradually gaining ground here.

Geneva.—The electric light was temporarily employed here during the occasion of the festival in August last, Thomson-Houston lamps being used in the Rue du Mont Blanc and neighbourhood. It is proposed by a local company to put down a central station for supplying electric light generally, as soon as matters have been arranged with the authorities. The swift-flowing waters of the Rhone as they leave Geneva will form an excellent means of providing cheap motive power, as already 1,200 h.-p. is being developed by five turbines for other purposes, and the "Batiment des Turbines" is now being extended, which extension it is proposed to adopt for electric lighting at an early date.

AN ELECTRIC NIGHT LIGHT.

The accompanying illustration shows a little arrangement of Messrs. Woodhouse and Rawson, which is at once elegant and useful. It is often convenient at night to instantly obtain a light, and yet there are many objections to always have a light burning. The "tallow" men have long had it all their own way in providing night lights, but now electricity promises to supply something better. A small 1 candle-power 4 volt lamp is fitted near the bed's head,

the push to make contact being well within reach. With the lamp, if there is no dynamo or secondary battery handy, it is usual to supply a battery of four Leclanche cells. The whole is cheap, handy, and effective.

CORRESPONDENCE.

ELECTRIC LIGHTING.

[The following letter appeared in *The Times* of Friday last, in continuation of the correspondence commenced by Major Flood Page, whose letter appeared also in our last issue.—ED. *E. E.*] :—

SIR: The public are under a great obligation to your well-known correspondent, Major Flood Page, whose letter you printed yesterday, for his very clear and powerful advocacy of the strong claims of electric lighting on the immediate attention of Parliament. As he has referred to my Bill, which passed the House of Lords last year, and expresses in very kind terms the hope that I may re-introduce it this year, I beg to say that it is my firm intention to lay it again on the table of the House of Lords so soon as Parliament re-assembles. At the same time, I entirely concur with Major Flood Page in hoping that Government may see fit to deal with the question this Session, and enable me to withdraw my Bill and give my hearty support to their measure.

The only point on which a difference of opinion practically exists in Parliament is on Clause 27 of the Act of 1882, which governs the compulsory purchase of electric lighting undertakings by local authorities after 42 years (42 years being now generally conceded in place of the original 21 years).

The Board of Trade oppose any valuation of the "goodwill" of the business. We, on the other hand, feel that nothing short of a fair valuation of that asset will insure the public being well served during, say, the last ten years of the life of a provisional order. If the valuation for compulsory purchase by a local authority at the expiry of 42 years is made on narrow principles, such as mere break-up value, without a due regard to maintaining the thorough efficiency of the plant, we hold that there is a serious danger of electric lighting undertakings being allowed to run down towards the expiry of their term, to the detriment of the public.

It is, however, possible that sufficient, fair, and reasonable profits may be derived from the business during the period of 42 years to encourage the flow of capital into electric lighting undertakings which 21 years have failed to do; but we think it politic to give an electric lighting undertaking every encouragement to maintain its plant in the highest state of efficiency up to the expiry of its life of 42 years, and that for this purpose it is necessary "goodwill" should be considered as an asset for valuation in the event of compulsory purchase by the local authority.

If, on the other hand, it can be legally held and maintained that the valuation "as a going concern" sufficiently covers this point and affords sufficient protection to the public, I for one would be glad to drop the obnoxious word "goodwill."—Yours, &c.,

33, Chesham-place, S.W., Feb. 1. THURLOW.

COPPER IN DYNAMOS.

Our contemporary, *l'Electricien*, observes that a few years ago these machines were constructed quite empirically. The constructor made a machine, experimented with it, and by means of the results obtained he arrived at data for a type of machine of given power. But since then things have much altered; and it has frequently occurred that the same power has been obtained when the weight of copper in the field-magnets or in the armature has been very much reduced. In relation to this question, M. Wilhelm Peukert, of Vienna, has compiled the following table, published by our contemporary *Zeitschrift für Electrotechnic*:—

Machine.	No. of revolutions per min.	Dif. of potential in volts.	Electrical power in watts.	Total weight of copper in kilos.	Grams of copper per useful watt.
Crompton	400	600	72,000	637·1	8·85
Crompton	700	110	54,000	475·7	8·77
Ganz and Co. (V P_5)	670	105	50,400	240·0	4·76
Goolden and Trotter	765	56	16,000	104·6	6·54
Goolden and Trotter	1,070	77	22,000	104·7	4·67
Brush	400	80	300,000	3,000·0	10·0
Ganz and Co. (ring machine with six poles)	1,000	1,500	52,000	82·0	1·56
Crompton (type No. 30)	440	110	25,300	393·0	15·5
Mather and Plate	1,000	100	22,000	144·0	6·4
Lahmeyer.—G. III	1,250	65	3,900	50·3	12·89
H. Pöge	840	65	6,500	58·3	8·96
Bollmann	750	100	100,000	556·0	5·5
J. Einstein and Co.	1,100	100	4,500	35·0	7·7
Edison-Hopkinson	800	100	33,000	118·0	3·57
C. E. L. Brown	1,000	65	10,400	45·0	4·32
C. E. L. Brown	1,000	55	6,600	21·6	3·3
Brush	1,000	100	380,000	2,833·0	7·45
Elwell-Parker	1,000	110	50,600	454·0	9·1
E. Fein (interior pole machine)	520	110	15,000	88·4	5·88

It will be observed that machines made about three years ago gave 1 watt for every 30 or 35 grams of copper, whereas the machines of Ganz and Co., at the present day, give 1 watt for every 1·6 grams of copper.

Meteorological Society.—At the ordinary meeting of the society, to be held on Wednesday next, the following papers will be read:—"Electrical and Meteorological Observations on the Peak of Teneriffe," by the Hon. Ralph Abercromby, F.R.Met.Soc.; "Rainfall of South Africa, 1842-1886," by W. B. Tripp, M.Inst.C.E., F.R.Met.Soc.; "Some Methods of Cloud Measurements," by Nils Ekholm.

ON ALTERNATE-CURRENT TRANSFORMERS, WITH SPECIAL REFERENCE TO THE BEST PROPORTION BETWEEN IRON AND COPPER.*

BY GISBERT KAPP, MEMBER.

The principle on which all induction coils, and therefore all the different forms of alternate-current transformers, depend is that of a magnetic circuit interlacing with an electric circuit. In its simplest form this relation can be represented by two rings threaded through each other (Fig. 1), one representing the

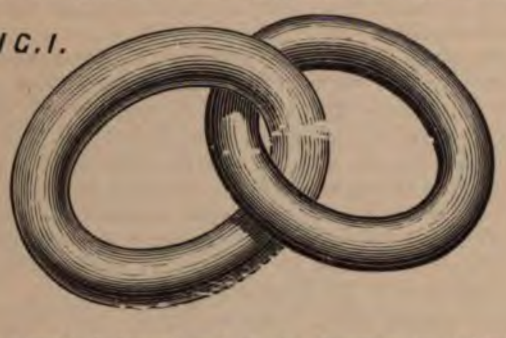


FIG. 1.

electric circuit (coloured red in the diagram to indicate the copper wire), and the other the magnetic circuit (coloured blue in the diagram to indicate the iron core). Modern transformers have all a closed core, so as to compel, as far as possible, all the lines of the magnetic circuit to pass through the electric circuit, which consists of a primary and secondary coil; but they differ from each other in the particular manner in which the circuits are arranged, with a view to attain the following objects:— Reduction of the length of the two circuits, reduction of the weight of materials employed, ventilation, facility of manufacture and repair, efficiency of insulation, and reduction of cost of manufacture. Omitting for the present those considerations which more nearly concern the practical manufacture, we may divide transformers broadly into two classes—one in which the copper coils are spread over the surface of the iron core, enveloping the latter more or less completely; and the other in which the core is spread over the surface of the copper coils, forming a shell over the winding. I propose to call the former "core transformers," and the latter, "shell transformers." A familiar example of the first class is the armature of an ordinary Gramme dynamo, whilst the particular type of transformer introduced by Mr. Zipernowski may serve to illustrate the second class. They are represented in the wall diagrams (Fig. 2 and 3), the copper being coloured red and the iron blue. It is evident without mathematical investigation that, whatever may be the proportion between the external and internal diameter of the ring, the electric circuit must be shorter than the magnetic circuit in the Gramme ring or core transformer, whilst the opposite must be the case in the Zipernowski ring or shell transformer. When, a few years ago, this type was introduced, it was, on account of its short magnetic circuit, generally believed to be an immense improvement upon the Gramme ring; and I have heard it stated that with the Zipernowski outside core absolute perfection has been reached, since "every inch of copper wire contributes to produce electromotive force." I propose presently to lay before you a short investigation into the relative merits of the Gramme and Zipernowski rings, and also into the best proportion of copper to iron in either; but before entering into this subject I would submit a few theoretical considerations, so as to obtain a basis for this investigation.

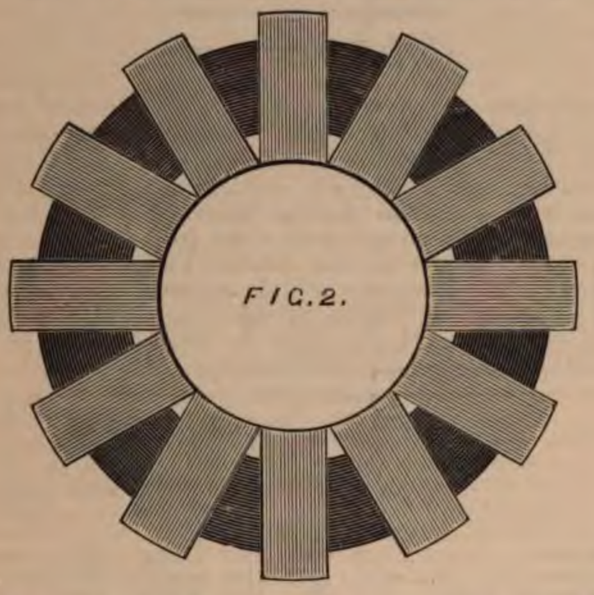


FIG. 2.

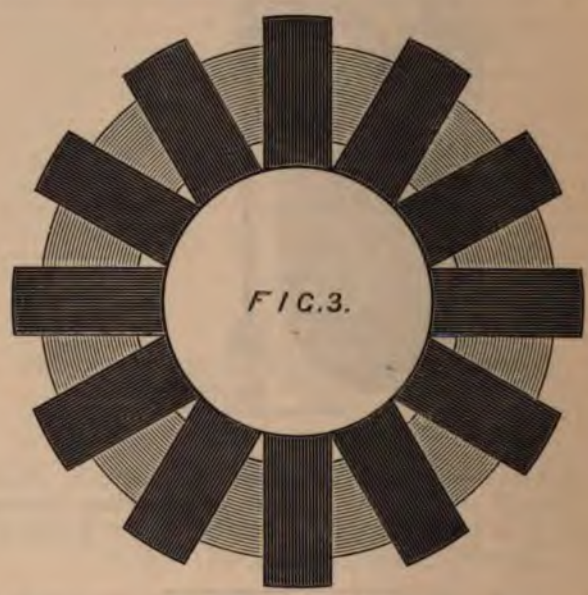


FIG. 3.

Since the electromotive force developed in the secondary circuit is proportional to the coefficient of mutual induction between that and the primary circuit, and since self-induction tends to produce lag and so reduce the output of the apparatus, it is obviously advantageous, both for efficiency and output, to so arrange the coils that their coefficient of mutual induction should be a maximum for the given coefficients of self-induction in the primary and secondary circuit. According to a well-known law, the maximum value which the coefficient of mutual induction can have is equal to the square root of the product of the two coefficients of self-induction; and the necessary and sufficient condition for obtaining this maximum is that the same number of magnetic lines of force should pass through both circuits. In other words, the whole of the flow of force should take place within the core, and no free poles should be formed. This condition can easily be fulfilled by a suitable arrangement of the two circuits in close proximity, and, as a matter of fact, is fulfilled in all modern transformers. We shall therefore assume that the same flow (F) of magnetic lines of force passes through both circuits, and that the electromotive forces produced in the two circuits bear to each other the same proportion as their respective number of turns. We shall further assume that the electromotive force impressed on the terminals of the primary coil, or the current sent through it, is a simple sine function of the time—in other words, that the electromotive force developed in the armature of the dynamo is such a function. Whether the latter condition is generally fulfilled by modern machines I am unable to say; but I believe that the presence of a transformer in the circuit has the tendency to smooth down any deviations from a true sine curve should they occur in the armature, and, further, that a curve of E.M.F., of whatever shape, produced by a machine will, after filtering through two or three transformers, come out as a true sine curve. It would be of value if someone having the necessary mathematical attainments would investigate this point; but for our present purpose it is sufficient to assume that the electromotive force produced by the machine follows with fair approximation a simple sine function, and that the deviations are unimportant. This assumption has up to the present been made by all who have investigated the subject of transformers.

Let in the following:—

n represent the number of complete cycles performed per second;
F ,, ,, flow of force in C.G.S. lines;
B ,, ,, maximum inductions (crest of wave);
r ,, ,, number of turns in the coils, the indices 1 and 2 being used to distinguish the primary from the secondary coil;
E ,, ,, maximum electro-motive forces (crest of wave) in volts, the indices 1 and 2 being used to distinguish the primary from the secondary coil;
$e = \sqrt{E}$,, average electro-motive forces;
I ,, ,, maximum currents;
$i = \sqrt{I}$,, average currents;
L ,, ,, length of the magnetic circuit in centimetres;

* Paper read at the Society of Telegraph-Engineers and Electricians, February 9th, 1888.

a represent the area of core available for the flow of lines in square centimetres ;

$R = \frac{L}{a}$,, ,, magnetic resistance of the core ;

μ ,, ,, its permeability ;

r ,, ,, the electric resistances :

then we have the following well-known relations :—

$$B = \frac{F}{a}\ ;\ F = \frac{\mu\, 4\, \pi\, \tau\, I\, 10^{-1}}{R}\ ;\ E = 2\, \pi\, n\, F\, \tau\, 10^{-8}\ ;\ \frac{E_1}{E_2} = \frac{\tau_1}{\tau_2}.$$

Calling e_{t1} and e_{t2} the average electromotive forces at the primary and secondary terminals respectively,

$$e_{t1} = e_1 + r_1\, i_1\ ;\ e_{t2} = e_2 - r_2\, i_2.$$

When a transformer is at work we have the following phenomena :—

1. A wave of impressed primary electromotive force.
2. A wave of counter electromotive force in the primary coil, but not exactly coinciding with the impressed.
3. A wave of primary current not coinciding with either.
4. A wave of magnetisation lagging behind the primary current wave by something less than a quarter period.
5. A wave of electromotive force in the secondary coil lagging behind the magnetisation wave by a quarter period.
6. A wave of secondary current, coinciding with the former (5) in period if the external circuit contain no self-induction—a condition approximately fulfilled where the current is only used for lighting glow lamps.

The problem now is to find what relations exist between these different waves as regards their relative positions and magnitudes. At first sight it may seem that this would prove a very difficult problem ; and if an algebraic solution be attempted it is, in fact, if not very difficult, at least enormously complicated ; but it is easy to treat the matter geometrically in a very simple way. As this method has already been published some time ago, it will not be necessary to demonstrate it, and I shall limit myself to a brief description, pointing out a modification of the original method by which the energy dissipated in magnetising the core can be taken into account. It will be seen from the above equations that F and E are proportional. Consequently, if we know what E.M.F. is to be put on the primary terminals of a given transformer, we also know with very close approximation what the induction and total flow of lines will be. If it were not for the slight disturbing influence of the resistance of the primary coil, we would know these data exactly. But the loss of E.M.F. by resistance can, for obvious reasons, only be trifling, and will in most cases be settled beforehand. We can therefore determine F with perfect accuracy, and from the constructive data of the core also the exciting power (τ I) which will produce this flow. It will be shown presently that it is inexpedient and uneconomical to work transformers with a high induction, and we may therefore regard the permeability to be constant for all points in the cycle. In this case τ I and F must at all times be proportional. Let, in Fig. 4, the circle represent the effective exciting power which we assume to coincide with the magnetisation, so that the projection on the vertical of the radius O P as it revolves (clockwise) round O represents the effective exciting power in ampere-turns, and, to a different scale, also the flow of force at any instant. The line representing the current in the secondary must evidently lag behind O P by a quarter cycle, and can be calculated from the formula for E_2, and from the resistance of this circuit. This gives us O I_2, the maximum exciting power due to the secondary coil alone. By erecting a vertical on O P in P, and making P I_1 = O I_2, we find the line O I_1, which represents in position and magnitude the maximum exciting power due to the primary coil alone. This gives us also the primary current, and we can now determine the loss of electromotive force due to the resistance of the primary coil. Let O R_1 represent this in direction and magnitude. The counter electromotive force in the primary must evidently be in advance by a quarter period over the magnetisation ; that is to say, it must be represented by a certain length on the line O Y. Its amount can be calculated from the formula for E_1. Let O E_1 represent it to the same scale as was used for O R_1 : then the parallelogram O R_1 Et_1 E_1 gives us at once the point Et_1 and line O Et_1, which represents in position and magnitude the maximum electromotive force impressed on the terminals of the primary coil, and a is the angle of lag of current behind impressed E.M.F. The work done on the primary coil is found by the well-known formula

$$W_1 = \frac{I_1 E_{t1}}{2} \cos.\ a\ ;$$

$$W_1 = i_1\, e\, .\ \cos\ a$$

That is to say, the true work is equal to the product of the apparent work, as measured by a dynamometer and voltmeter, and the cosine of the angle of lag. If the apparatus were supplied with current at a constant and unidirected E.M.F. the apparent and the true work would be equal, and the ratio $\frac{1}{\cos.\ a}$ indicates how much larger must be the capacity of an alternate-current plant to do the same true work as a continuous-current plant. I propose, therefore, to call cos. a the "plant efficiency" of the transformer.

It was stated above that transformers should be worked at a comparatively low induction. This might seem at first sight a retrograde step, since with dynamo machines considerable gain in efficiency and output has resulted from adopting an induction up to 20,000 and more ; but by reference to Fig. 4 one of the reasons why a low induction is preferable will be at once apparent. Suppose that the line O P represents the limit to which the induction may be pushed without diminishing the permeability : then, if the same transformer be worked at double the electro-motive force, we would require an exciting power not only twice, but many times, as great as previously. This would bring the point P considerably to the left without increasing the length of the line P I_1. It would also increase the length of the line O I_1—that is, the primary current—and therefore the heat generated in the primary coil, whilst the angle of lag would become greater and the plant efficiency smaller. Similar results would follow from an increase in the magnetic resistance of the core, or from the omission of a core altogether. An early type of transformer made by Messrs. Gaulard and Gibbs had no iron core, and therefore no well-defined magnetic circuit ; but as the primary spirals alternated with the secondary spirals our previous assumption regarding the coefficient of mutual induction remains valid, and the above formulæ and graphic method could be applied to this apparatus if we knew what value to assume for the resistance of the magnetic field. This, however, we do not know ; but the case is of no importance at present, as transformers without iron cores have become obsolete. I only mention this early apparatus because the experimental investigations of Dr. Hopkinson and Prof. Ferraris* have proved that there is a considerable difference between the apparent and the true work—that is to say, the point P must have been a considerable distance to the left, making the plant efficiency small. In modern transformers the point P lies so close to O that the plant efficiency may reach as high as 99 per cent., so that the difference between real and apparent work supplied to the apparatus when giving full output becomes trifling ; and for a practical determination of efficiency the readings of measuring instruments on the primary and secondary circuit may be used, with only such corrections as may be applied from the diagram.

A high plant efficiency is, however, not the only reason why transformers should be worked at a low induction. A far more important reason is the heating which takes places in the iron of the core if this be carried rapidly through cycles of intense magnetisation. This heating is not due to eddy currents (although these currents in a badly designed core would produce the same effect), but seems to be the result of what may be termed dissipation of energy by molecular friction or hysteresis. The energy dissipated per cycle per cubic centimetre increases in more than simple ratio with the induction, and it seems also to increase as the periodic time decreases. As yet very few experiments have been made to determine the hysteresis for different samples of iron, the most important data published being those given by Prof. Ewing and Dr. Hopkinson in the *Philosophical Transactions*, Part II., 1885. Prof. Ewing distinguishes between static hysteresis (slow period) and viscous hysteresis (quick period), but the experimental data refer only to the former. According to Dr. Hopkinson, the energy required to carry one cubic centimetre of annealed wrought iron through a complete cycle of induction equal to 18,251 lines is 13,356 ergs, and for hardened tungsten steel with an induction of 14,480 lines the energy reaches 216,864 ergs. Prof. Ewing found that with very soft annealed wrought iron and B = 13,190 the energy dissipated by hysteresis was 9,300 ergs. He also tested annealed iron wire by carrying it through lower cycles ; and, as the results are of very great importance in the construction of transformers, they are given herewith :—

Induction.		Energy.	Induction.		Energy.
1,974	...	410	10,590	...	5,560
3,830	...	1,160	11,480	...	6,160
5,950	...	2,190	11,960	...	6,590
7,180	...	2,940	13,700	...	8,690
8,790	...	3,990	15,560	...	10,040

These figures refer to static hysteresis. As regards viscous hysteresis, no experiments have been made ; but in the case of B=8,500 and n=80 Prof. Ewing estimates the energy dissipated per cycle at 5,000 ergs, or 32 per cent. above that of static hysteresis. When applying the figures of the table to transformers, it may, therefore (until further experiments have been made), be advisable to add from 30 to 40 per cent. to the energy there given. Thus, if an induction of 18,000 be adopted,

* "Ricerche Theoriche e Sperimentali sul Generatore Secondario Gaulard e Gibbs," by Galileo Ferraris. Turin, 1885.

the energy dissipated would amount to 18,000 ergs per cubic centimetre per cycle; and with 80 cycles per second this corresponds to ·144 watt per cubic centimetre of core. It would evidently be extremely difficult, if not altogether impossible, to provide cooling surface enough for this rapid generation of heat, and hence it is necessary to work at a lower induction, the exact amount to be determined for each transformer by the cooling surface of the core and coils, and by the heat generated in the coils themselves. So far, then, theory points to the necessity of low induction. As regards practice, I believe the makers of transformers have already found out that it does not pay to press the iron magnetically too hard. My own experience was at least in this direction. In the first transformer which I designed jointly with Mr. W. H. Snell, and which is on the table, we worked at an induction of 20,000, and there were produced two very undesirable results. In the first place, the core heated to such a degree that continuous work was out of the question; and, in the second place, the apparatus emitted a most unmusical sound, and it was evident that on this account alone it was not fit for practical use. The sound may have been partly due to the employment of wood for the framework, but we believed that the high induction was principally the cause, and by dropping the E.M.F. so as to get an induction of 15,000 we found that these evils were lessened. We then constructed another transformer, in which the induc-

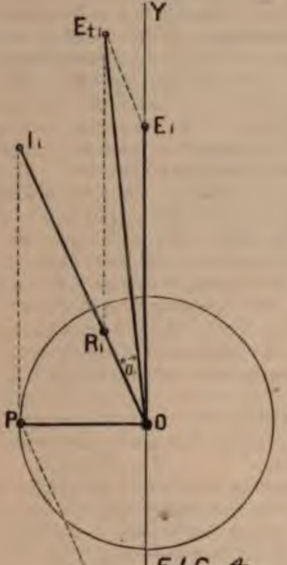


FIG. 4.

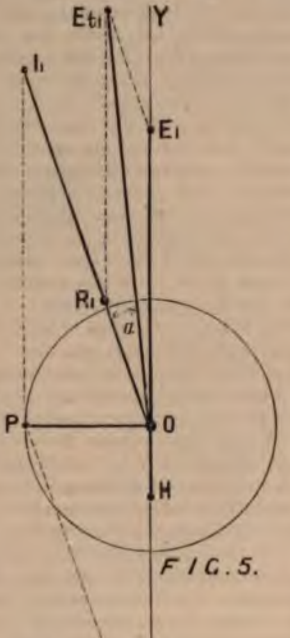


FIG. 5.

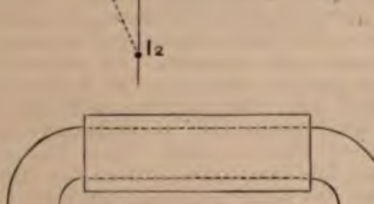


FIG. 8.

tion was reduced to 10,000. This transformer is also on the table. In it the sound was suppressed, but the temperature still rose by about 30deg. C. when continuously at work. We have therefore, in a later design, adopted a still lower induction. Although it is possible to reduce in this manner the amount of energy dissipated in the core, this waste cannot be entirely prevented, and must therefore be taken into account when determining by the aid of the diagram the working conditions of the apparatus. For this purpose it would, strictly speaking, be necessary to know, in addition to the total energy dissipated per complete cycle, also the rate of dissipation at each point of the cycle—a knowledge which we do not possess. It seems, however, reasonable to assume that the rate of dissipation of energy by hysteresis follows the same law at the rate of dissipation of energy due to eddy currents—that is to say, that it is proportional to the rate of change of induction. When the induction passes through zero the rate at which heat is generated would be a maximum, and this would gradually diminish to zero as the induction approaches its positive or negative maximum. On this assumption we can imagine eddy currents substituted for hysteresis; and in an iron core perfectly devoid of the latter property—that is, infinitely soft—the same amount of heating could be produced by imperfect subdivision, or, better still, by subdividing it perfectly, but wrapping round it a closed conductor of such a resistance that the heat generated in this conductor equals that dissipated by hysteresis in ordinary iron. For the ordinary transformer consisting of a perfectly subdivided core of iron not infinitely soft and a primary and secondary coil, we would substitute an imaginary transformer consisting of a perfectly subdivided core of iron free from hysteresis, a primary coil, a secondary coil, and a third closed coil of suitable resistance. The current in this third coil would coincide with that in the secondary coil, and its exciting power would be added to that of the secondary coil. For example, let the volume of iron affected by hysteresis in a particular transformer be 1,000 cubic centimetres, and let the energy of hysteresis be 5,000 ergs: the total energy dissipated would, with 80 cycles per second, amount to 40 watts. If the electromotive force produced in the secondary coil be 100 volts, then our imaginary third coil would have either the same number of turns as the secondary

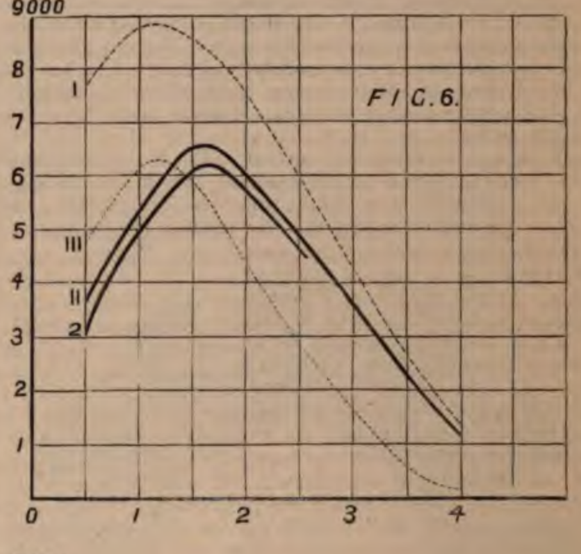


FIG. 6.

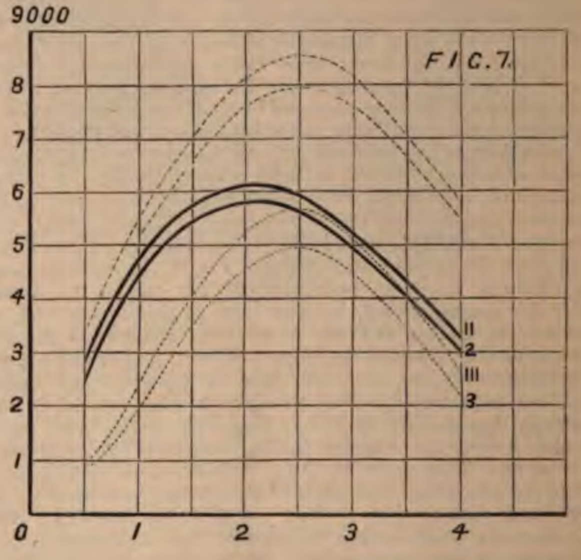


FIG. 7.

coil and a resistance of 250 ohms, or it might have half the number of turns and a resistance of 62·5 ohms, or any other combination giving the same loss of energy. The mean value of the fictitious exciting power would in all cases be the same, viz., the number of turns in the secondary coil multiplied by ·4 ampere. Let, in Fig. 5, O H represent the maximum value of this exciting power due to hysteresis; then the total exciting power tending to demagnetise the core, and which must in a certain measure be balanced by the exciting power of the primary coil, is represented by the length O I—being the sum of O H and H I_2, where H I_2 equals O I_2 of Fig. 4—and the point I_1 will be pushed higher up as compared with Fig. 4. The net result of this alteration is an increase in the amount of energy which must be supplied to the primary coil. It is thus possible to include the effect of hysteresis in the geometrical methods of representing the working conditions of a transformer. I have dwelt at some length on this question, because, notwithstanding its apparently somewhat abstruse character, it is really of very great practical importance. In some transformers the heat generated in the iron core is in excess of that generated in the copper coils, even at full output. Now, where transformers are placed in parallel between high

potential mains, it is, for obvious reasons of safety, not advisable to allow customers to handle a switch on the primary circuit, and the current must therefore be on, whether lamps are being lighted from the secondary or not. When the supply is continuous, as it obviously must be in a general system, the cyclic changes of magnetism in the core of every transformer will be kept up day and night; and the question of heating becomes of far greater importance than is the case in dynamo machines, which, as a rule, are only worked for a certain number of hours per day.

On the basis of the foregoing we can now investigate the relative merits of the Gramme and Zipernowski rings, and the best proportion of copper to iron in each. I have selected the two original types and one modification of each as being fair representatives of the two large classes into which in the beginning of this paper I have divided all transformers. These "rings" are both equally difficult to manufacture, and contain serious practical defects; but from a purely electrical point of view they are probably as good as the majority of transformers now in the market. Their practical defects constitute for my purpose a positive advantage, because nobody will care to claim either as his special type, and I shall thus escape the somewhat invidious task of having to compare the actual transformers made by rival manufacturers. As it is obviously impossible to conduct an investigation of this kind on absolutely general lines, it was necessary to assume rings of definite dimensions. I have selected rings of circular section having an internal diameter of 20cm. and an external diameter of 42cm., shown in full size in the wall diagrams (Figs. 2 and 3). The mean primary potential is assumed to be 2,000 volts, and the secondary 100 volts. The copper coils in Fig. 2 and the coils forming the iron shell in Fig. 3 are supposed to touch each other on the inside, and, being of equal depth all round, to separate on the outside, exposing part of the inner ring. In the Zipernowski transformer as actually made the inner diameter of the ring is rather smaller than shown in Fig. 3, and the shell winding covers the whole surface of the conductor, being of less depth on on the outside than on the inside; but the magnetic resistance is in either case so low that the difference between the assumed and actual arrangement does not materially affect the result, whilst the calculations for the former are somewhat less complicated. The total space occupied by insulation I have assumed to be 1cm., or 2·5mm. between the core of the Gramme ring and the primary coil, and 2·5mm. between that and the secondary coil. The same space has been allowed for the Zipernowski ring. We can now assume different sectional diameters for the inner ring (core or coils), and depth of winding for the covering (coils or shell), so as to make up the 11cm. sectional diameter of the whole ring; and determine the output for each combination so that for continuous work the apparatus should keep moderately cool. From analogy with dynamos I estimate the total energy which may be wasted without producing overheating at 260 watts; and the output has in all cases been calculated on this basis for an induction of 8,500, a periodic time of 1-80sec., and hysteresis at 5,000 ergs. As it would serve no useful purpose to burden this paper with a reproduction of the somewhat lengthy calculations, I have plotted the results in the curves II. (Figs. 6 and 7). The curves I. show the output which might be obtained if hysteresis did not exist, in which case the whole of the 260 watts would be transformed into heat within the coils. The thickness of copper winding (Fig. 6), and that of the iron shell (Fig. 7), is plotted on the horizontal; the output on the vertical. From Fig. 6 it will be seen that the maximum output with the Gramme ring is 6,400 watts with a thickness of copper winding of about 1·7cm., leaving 6·6cm. for the sectional diameter of the core. The cross-sectional area of the magnetic circuit is in this case about 80 per cent. of the cross-sectional area of the electric circuit, and the gross volume occupied by iron is about equal to the gross volume occupied by copper. The maximum output for the Zipernowski ring (Fig. 7) is 6,100 watts for an iron shell 2cm. thick, leaving the sectional diameter of the coils 6cm. The cross-sectional area of the magnetic circuit is in this case nearly eight times that of the electric circuit, and the gross volume occupied by iron is $1\frac{1}{4}$ times that occupied by copper. Thus, with the same external dimensions, the Zipernowski ring gives a slightly lower output than the Gramme ring; but it must be remembered that the weight of copper is also slightly smaller. I have made the same calculations for oblong rings, as shown in Fig. 8. Imagine the Gramme ring cut in halves, these straightened and laid side by side, and the two cores joined by semicircular pieces at the ends. The copper coils will in this process not be altered, but the length of the magnetic circuit and the volume of iron in the core will be increased; hence more energy will be absorbed in hysteresis, and the output will be reduced. In Fig. 6 the curve 2 represents the output for the oblong Gramme ring. By adopting the oblong shape for the Zipernowski ring we do not alter the mass of iron in the shell, but we lengthen the electric circuit, and increase the waste of energy in the coils. In this case also the curve of output 2 (Fig. 7) must lie below that of the circular type. Curve 1 (Fig. 7) shows the output of the oblong type if there were no hysteresis. In Fig. 6 this must obviously coincide with curve I. The maximum output of the oblong type is—for the Gramme ring, a little over 6,000 watts; and for the Zipernowski ring, 5,800 watts.

Up to the present we have only considered the output as limited by the amount of energy which may be wasted without overheating. But there is another and equally important consideration which affects the output, namely, the question of self-regulation. It is evident that in a transformer fed at a constant potential the induction is a maximum when the secondary circuit is open, for in this case the counter electromotive force of the primary is very nearly equal to the electromotive force at the terminals. At full work the two differ by the amount lost in resistance, and the induction is reduced in the same proportion. The electromotive force generated in the secondary coil is proportional to the induction, and we must deduct from it the loss in resistance in order to obtain the external electromotive force. Thus, if 1 per cent. be lost by resistance in the secondary, and 1 per cent. by resistance in the primary, the difference of available electromotive force between open circuit and full output will be 2 per cent. For good lighting this may be considered the permissible limit of variation, and on this basis I have calculated the output of the four transformers above described. Curve III. in Fig. 6 gives the result for the circular and oblong Gramme ring. It will be seen that with a stout core the limit of output due to heating is reached sooner than that imposed by the condition of self-regulation, whilst for thin cores the reverse is the case. The best proportion of iron to copper is indicated by the intersection of curves III. and II. for the circular, and III. and 2 for the oblong transformer. In the latter case the core would have to be 7·2cm. in diameter, and the winding would have to be 1·4cm. deep. The output is 5,900 watts. For the Zipernowski ring curve III. gives the output as limited by self-regulation in the circular, and curve 3 in the oblong type. The diagram shows that the limit of output imposed by the condition of self-regulation is in all cases reached sooner than that due to heating. For the oblong transformer the maximum output is slightly below 5,000 watts, and the best proportion of iron to copper is given by the abscissæ of the highest point of curve 3. The external shell would have to be 2.4cm. thick, and the sectional diameter of the coils 5.2cm. From the above figures it appears that in the circular and in the oblong type the Gramme ring, dimensioned as shown in Figs. 2 and 8, gives more output than a Zipernowski ring of the same over all dimensions; the latter is therefore not superior to the Gramme ring, as commonly supposed, but somewhat inferior.

It might be, perhaps, objected that I have selected proportions different from those found in actual circular shell transformers, which have a much stouter ring of smaller mean diameter. More of the internal space is filled by the shell, and the central hole left is much smaller than shown in Fig. 3. The iron wire forming the shell is not put on in regular layers, but the turns cross each other in a more or less confused manner. There is no objection to such winding from an electrical point of view, as perfect insulation between the wires is of small importance. For the Gramme ring such winding would, on the other hand, be quite inadmissible; and it is on this account that I have selected a somewhat larger internal diameter of the rings, which gives rooms for regularly wound coils. But even if the rings are much stouter their proportion of output is not materially altered. If we imagine the ring of Fig. 3 contracted so as to reduce the central opening to 10cm. and the extreme diameter to 32cm., we obtain about the proportion of a Zipernowski transformer.

For convenience of calculation I have assumed a ring of these proportions to be changed into the oblong type, as shown in Fig. 8, but with this difference—that the external winding (coils or shell) on each side is only 15·7cm. long instead of 31·4cm.; the diameter being 11cm., as before. Calculating the output in the same manner as before, I find that for the core transformer the maximum output as limited by heating is 3,230 watts, and is reached when the copper winding is 2cm. deep; whilst the maximum output as limited by the condition of self-regulation (within 2 per cent.) is 3,020 watts, and corresponds to coils wound 1cm. deep. The two curves cross each other, as in Fig. 6, and the ordinate of the crossing point corresponds to a maximum possible output, as determined by the joint limit of heating and self-regulation, of 2,950 watts with coils wound 1·3cm. deep. In the shell transformer the limit of output due to heating is 3,030 watts when the shell is 2cm. thick, and the limit of output due to self-regulation is 1,650 watts when the shell is 2·2cm. thick. These figures show that even in stout rings, having proportions more nearly comparable with those of the Zipernowski transformer as actually constructed, the core type is better than the shell type.

This result refers, however, only to transformers having a core or a shell of circular section; and the question is whether by an alteration in the form of the shell the shell transformer could be improved. Any departure from the circular form of the shell must increase the length of the magnetic circuit, and must so far be detrimental; but if we can at the same time reduce the length of the copper coils, this disadvantage may be more than balanced by the reduction in the resistance of the circuits. As

a matter of fact, the magnetic resistance of the shell is so low that even a considerable increase in the length of the magnetic circuit does not materially affect the difference of phase between the primary and secondary current. The two are almost diametrically opposed whatever may be the magnetic resistance. We can, therefore, adopt any shape of shell which will allow the length of the copper coils to be reduced. This is actually done in most modern transformers. The shell is rectangular, with the short side of the rectangle parallel to the plane of the coils, and thus the mean diameter of the coils is reduced. In addition to this, the circular form of coils has been abandoned in several of the more modern transformers, so that the shell may fill more or less completely the interior of the coils.

In core transformers as now generally made the coils are not arranged all over the core, but are disposed in two sets, one on each limb of a single core. Each set of coils contains a primary and secondary circuit wound upon each other, or one between the other, so as to obtain perfect symmetry. Were this not so, and were one limb wound with the primary and the other with the secondary, external poles would be formed at opposite points of the core, and the output would be reduced. In a similar manner the coils in shell transformers are wound upon or in between each other, but there is generally only one set of coils and a double core. The distinctive characteristics of the two types are therefore as follows :—

Core transformers—One core and two sets of coils.
Shell transformers—Two cores and one set of coils.

The following are some of the principal modifications of each type:

Core transformers—Gaulard and Gibbs, Lowrie-Hall.
Shell transformers—Zipernowski, Ferranti, Mordey, Wright, Kennedy, Statter, Westinghouse, Snell and Kapp, Gaulard and Gibbs.

As most of these transformers are on the table, I need not describe them at length. The original Gaulard and Gibbs transformers had an open magnetic circuit, and cores which could be more or less inserted into the coils so as to regulate the E.M.F. of the secondary—a provision obviously necessary where the transformers are coupled in series. In the apparatus shown in 1883 at the exhibition in the Aquarium, there were four distinct induction coils ; and in that employed for lighting on the Metropolitan Railway in 1884 there were 16 distinct induction coils, the circuits being formed by a compound cable consisting of a central primary wire and six secondary wires grouped round it. In 1885 was introduced a type of transformers with closed magnetic circuit, in principle identical with that shown in Fig. 8, but the two limbs further apart. In the same year Messrs. Gaulard and Gibbs introduced small shell transformers in their Tivoli installation, each transformer feeding one 50 candle-power lamp. The two circuits are formed by a compound cable coiled into a solenoid, through which is passed a bundle of iron wires ; the projecting ends are then bent over to close the magnetic circuit on the outside of the solenoid, and the whole is encased in a perforated metal cylinder with wooden ends. In their latest design of transformer the coils are circular in plan and rectangular in section, and are surrounded by groups of U-shaped soft iron stampings slipped over from both sides and held together by two circular cast-iron plates with a central bolt. The primary circuit is split up into two coils, with the secondary between them.

In the Lowrie-Hall transformer there are two sets of primary and secondary coils, laid horizontally one above the other. The core is formed by thin, broad sheets of soft iron insulated from each other by varnished calico, and the projecting ends of these plates are alternately bent up and down respectively so as to complete the magnetic circuit, the whole being clamped together in a horizontal cast-iron frame. The Ferranti transformer is similar in the mechanical arrangement, but, belonging to the shell type, has only one set of coils of rectangular section. The core is formed of thin iron strips of moderate width insulated from each other, doubled over at the ends, and clamped in a cast-iron frame. Mr. Rankin Kennedy has devised various transformers of the shell type. For the general supply of alternating currents he proposes to use a main current transformer at the generating station, in which currents from low-tension dynamos are to be converted into high-tension currents to be sent into the mains. The shell of this transformer is built up of moderately wide but very thin strips, to form a rectangular frame of considerable depth, the strips being fastened by bolts at the corners. The core is composed of a series of strips of double width passing like a web through the middle of the opening of the rectangle, and thus subdividing it into two openings through which the winding passes. In another type, which Mr. Kennedy calls the "piled form of subdivided transformer," the iron portion consists of H stampings, in which the central web forms the core and the two down strokes of the H the shell, the coils being wound over the web. A number of these wound frames are piled upon each other, and side by side, the whole being clamped between cast-iron covers. Diagramatically, this construction can be represented by Fig. 1 if, instead of employing only two links, we use a number of them formed into a chain consisting alternately of copper and iron circuits. In another form of apparatus Mr. Kennedy uses a Siemens shuttle armature overwound with a shell of iron wire. Mr. Wright's transformer may be described as a Zipernowski ring with coils of rectangular section and a shell of rectangular iron frames instead of the original iron winding. Each frame is cut across a corner, so that it may be placed over the core ; and as the edges are packed close on the inside, but radiate on the outside of the ring, the frames form gills for the dissipation of heat. In Mr. Mordey's transformer the shell consists of thin rectangular iron plates with a rectangular opening, the strip cut out being laid across the frame to form the core of the coils. The ratio in the length of the sides of the rectangle must evidently be as 4 : 6, and that of the strip cut as 2 : 4, in order to obtain a uniform section throughout the magnetic circuit. The apparatus is built up by alternately slipping a frame over and a strip through the coil. The core of the Westinghouse transformer consists of rectangular frames, each with a central web connected to the frame on one side only, so that it can be bent back to slip over the coils. The whole is mounted in a cast-iron weather-proof box for outdoor use. The shell in Mr. Statter's transformer consists of E-shaped stampings slipped over the coils alternately from either side. To obtain the same area of iron throughout, the width at the bottom of the stamping is twice that of the limbs. In the transformer designed by Mr. Snell and myself the shell consists of U stampings forming a double trough into which the coils are laid. The covers of these troughs are formed from the metal removed from the interior of the stampings. The whole is held together in a cast-iron frame so arranged as to allow air to circulate through the core and round the coils.

To render transformers perfectly safe it is necessary to avoid leakage between the two coils. For this purpose Mr. Kent has devised a very simple apparatus, consisting of an insulated sheet of metal wrapped round the inner of the two coils, but not forming a closed circuit in itself. This sheet of metal, which thus separates the two coils completely, is connected to earth. Now, if the insulation of the primary coil should fail, the leak, before reaching the secondary coil, must pass through the sheet of metal, and is thus conducted to earth, causing the primary cut-out to melt, and thus cutting the faulty transformer out of circuit. Another safety appliance has been devised by Captain Cardew. Its object is to disconnect the primary circuit from the mains if any part of the secondary circuit acquires a certain potential above that of the earth, which will take place if a leak occurs between the two circuits. The apparatus consists of a cast-iron box on the bottom of which is laid, into a shallow recess, a strip of platinum foil terminating at both ends in circular discs. About one-eighth of an inch clear above one of these discs is set a metal disc with screwed stem at the back passing through the glass cover of the box, and connected by a fine fuse wire with any point of the secondary circuit. The box itself is connected to earth. The fuse wire holds back a contact spring so arranged that on breaking of the wire it will fly down to its contact and short-circuit the primary terminals of the transformer, after which its own primary fuse will melt and cut off the supply of current. If the potential between earth and the insulated disc in the box should rise above a certain limit (which can be regulated by screwing the disc up or down) the static attraction between the disc and aluminium foil lifts the latter into contact, allowing a leakage current to pass through the fuse wire of the contact spring, and thus releasing the latter. I am told by Captain Cardew that this apparatus has been tried at the Grosvenor Gallery installation, and been found to act in a perfectly reliable manner.

In the present paper I have only dealt with what may be called elementary principles in the construction of transformers. As, however, the application of transformers is a matter of far greater importance to our profession at large, I trust you will allow me to say a few words on this subject, not with the object of imparting information, but in the hope that a discussion of real practical value may be the result. Up to the present, distribution by tranformers has been made either on the single-series or the single-parallel system ; compound parallel, the three-wire system, or any other refinement of direct-supply methods, have, to my knowledge, never been attempted with transformers. The series system must fail for want of self-regulation where the lamps are to be connected in parallel and controlled independently of each other ; but for very extensive and sparsely-lighted districts, with the lamps supplied by each transformer in series on the Bernstein system, a series arrangement of transformers will admit of perfect self-regulation, provided the primary current be kept constant, and will, moreover, be cheaper than the parallel system. For general purposes, and especially for the dense lighting required in towns, the only practical method at present in use is to connect the primary terminals of the transformers all in parallel, and the lamps also in parallel, across the secondary circuit of each transformer. In principle this arrangement is adopted in England, America, and on the Continent ; but the methods differ in these countries. Here the distribution is made by a high-tension network of mains, and the transformer of each subscriber is directly connected with the mains. In America a double network of overhead mains is employed, one for the high-tension and the other

for the low-tension currents. These mains are supported generally on the same poles, to which are also fixed the transformers, and the subscriber's connection is made with the low-tension mains wherever convenient. On the Continent a network of low-tension underground mains is used for distribution in the same way as if the supply were on the direct system, and this network is fed by alternating currents at certain points where fairly large transformers are installed. The primaries are connected with the station either by overhead wires or by a special kind of cable containing two circuits insulated from each other and arranged concentrically. The cable is protected by a double lead covering and by an iron sheath formed of spirally wound tape. Of the three methods here described our own appears to be the worst, the American slightly better, and the Continental the best. To string high-tension wires over and across our streets, allow high-tension branch leads to pass into our houses, and give every subscriber a little transformer to himself, more or less within the reach of the inmates, seems to me to be positively courting disaster. Such rough and ready methods may do as long as the light is not generally installed throughout a district; but once assume that every householder is using it (and it is that we are hoping for), the thousands of branch wires and transformers in the houses must constitute a very serious element of danger. In the American plan the high-tension wires are not brought into the houses, and in so far there is little danger to the inmates; but, of course, in the streets there is the same danger as here from the overhead wires.

Now the Continental plan may almost be called absolutely safe. With an arrangement like Mr. Kent's dividing sheet to prevent leakage, or Captain Cardew's ingenious apparatus for detecting it and cutting off the supply, the secondary circuit can never acquire a potential sufficiently high to endanger life or property. This network can be composed of comparatively light cables, because we can feed it at frequent intervals and thus insure constancy of pressure at all places and at all hours. The transformers would be fairly large—say from 500 to 1,000 lights each—and could be installed in rooms to which no person but the authorised attendant has access; and by placing the primary feeding mains also underground accidents would be rendered almost impossible. The method of using an underground secondary distributing network has also the advantage that, should at any future time storage batteries become sufficiently improved to render distribution by continuous currents possible, the whole of the cables would be available for this purpose without any change.

ELECTRICAL MEASUREMENTS, ESPECIALLY AS APPLIED TO COMMERCIAL WORK.

BY PROF. WM. A. ANTHONY.

(*Concluded from page 116.*)

A form of instrument known as the Wirt voltmeter, as furnished by the Electrical Supply Company, of Chicago, uses the Daniels cell, of special construction, as a standard. The cell consists of three square bottles cemented together side by side. In one of the outside bottles is the zinc in zinc sulphate, communicating with the middle bottle by a small hole near the top. The other outside bottle contains the copper in copper sulphate and communicates with the intermediate bottle by a hole near the bottom. In the middle bottle is a valve which when closed prevents communication between its upper and lower parts, and so prevents the mixing of the two liquids. This valve is to be opened only at the time of making an observation. No doubt such a cell made up from pure materials would give the same potential for a considerable time.

I have so far avoided the use of the term electromotive for I find there is a good deal of confusion as to the exact use of it even among physicists. I find it stated in some works of high authority that electromotive force and difference of potential are synonymous terms, and again that difference of potential produces electromotive force. I have seen it stated in a very excellent text-book on electricity by one of our foremost electricians, that the electromotive force of a voltaic cell is the result of the difference of potential between the poles.

I can best illustrate what I conceive to be the difference between the two terms by referring again to the analogy between the electric flow and the flow of fluids. Gas is flowing through this pipe. Take two points, A and B, and suppose the flow to be from A towards B. A pressure gauge would show a higher pressure at A than at B. Water flows in your water mains. A pressure gauge will show a higher pressure at any point than at any other point further on in the direction of the flow (it is supposed that the points considered are at the same level). The difference of pressure is the cause of the fluid flow. It is the force that moves the fluids, the *fluid-motive force*. Electricity is flowing along this wire.

I have shown that there is a difference of potential between the different points along the wire, and we accept that difference of potential as the cause of the electric flow between the two points. If we know nothing of the pipe except between the two points considered, we cannot assign any other cause for the flow of the fluid through it except the difference of pressure, but we know the difference of pressure must have a cause, and if we are at all inquisitive we shall not be satisfied with saying the difference of pressure is the fluid-motive force, but we shall trace the pipe back and try to discover the cause of the difference of pressure. Tracing the pipe back we find, by-and-bye, a stand-pipe in which the water level is far above any of the outlets from which water is drawn. This accounts for the pressure of the water in the pipes, but still we are not satisfied. There must be a cause for the high level in the stand-pipe. Investigating further, we find a system of pumps which forces the water into the stand-pipe, taking the water, perhaps, from the same level to which our pipes discharge it. Here we find a water-moving force that is not water pressure, without which the pressure that moves the water in our pipes would soon cease, and the flow stop.

Suppose now that all our outlets are stopped, and that no water flows from the stand-pipe. What results? The pumps go on working, the water in the stand-pipe rises higher and higher, and if the pipe is high enough and strong enough the water will rise till the force of the pumps is balanced, and they will stop. The pressure now exerted by the water column measures the water-moving force of the pumps. We can tell by it just what is the force we have at command for moving water. This force is the water-motive force of our system. It must be sufficient to overcome the resistance of our pipes, and carry the water to the highest levels we wish to reach when the flow is most rapid. Open a cock, the water flows and lowers the level in the stand-pipe, the back pressure upon the pumps is diminished, they begin to work, and maintain the water at nearly its former level. Open another cock, the levels falls a little more, and the pumps work faster. Make more and more openings and the water in the stand-pipe falls more and more till, by and by, the level in the pipe is but little above that of the supply from which you pump. Water is being used at such a rate that the force of the pumps is little more than sufficient to drive the water through their own passages. It is not the water-motive force that has failed, but the carrying capacity of the pumps.

Now note the analogy in the case of the voltaic cell. We have found on this wire a difference of potential from point to point. Trace the wire back and we find an apparatus whose office it is to maintain the potential difference. What is its action? By some means, which we do not understand as well as we understand the action of a water pump, this apparatus takes electricity from one of the plates, N, in the liquid and forces into the other, P. In the second plate, P, the electricity is at a higher level, and so flows through the wire to the plate N to be forced back to P through the liquid. Cut the wire and almost at once the electricity in P reaches the highest pressure, level, or potential, that the cell can produce. All action in the cell ceases, and the difference of potential between it and P now measures the force the cell can exert to move electricity, the *electromotive force* of the cell. The electromotive force is something that depends upon the materials of which the cell is made and is absolutely independent of its size. The smallest cell, one made of a copper musket cap holding a drop of water, and a bit of zinc of the size of the point of a pin, as I have often shown experimentally, has the same electromotive force as a cell of the same materials of the largest size; just as the water-motive force of a small pump, its power to produce pressure may be just as great as that of a larger one. Let us follow the analogy. I connect P with N by a small wire. This is like opening a single stopcock on our water service. The electric level is lowered, but the cell begins to work and maintains the potential at very near its highest value, another wire allows more electricity to flow, still more lowering the potential, and it is possible to open so free a path for the passage of the current that the cell can no longer maintain a considerable potential difference, and the limit of the capacity of the cell to supply electricity is reached.

Note that the limit here is not due to any falling off of electromotive force, but to the fact that nearly the whole electromotive force is required to carry so much electricity across the liquid from plate to plate. Here exactly is the advantage of a large cell over a small one—a large cell, like a large pump, can maintain a high pressure, even when there is a large draft upon it. I think you will now see the distinction between the terms difference of potential and electromotive force. Difference of potential is *one* electromotive force. But the general term, electromotive force, includes all causes of the movement of electricity. There may be a flow of electricity without a difference of potential, but there can never be a flow without an electromotive force.

I could give you examples of a great variety of electromotive forces, but one more will suffice.

I move this rod across the earth's magnetic field. I know that an electromotive force is developed, causing a flow towards the end at my left hand. That end, I am sure, is for the moment at a higher potential. When I stop, the electricity flows back and equalises the potential. Connect the two ends by a wire leading to a sensitive galvanometer, and the flow of current is demon-

strated. This movement of a wire across any magnetic field develops a difference of potential between the two ends, and if the wire form a closed circuit, a current will flow. I said just now that we could have a flow without difference of potential. Here is a case. A magnet thrust end-on into the centre of a wire hoop produces an electromotive force, which acts equally all round the hoop, causing a flow, but without difference of potential. Here, too, we may find an analogy in the flow of liquids. Suppose a trough in the form of a ring to contain fluid, and let an endless rope be laid in it, and made to move around the trough. (Illustrated on black-board.) The liquid will be dragged along by the rope, but there is no difference of pressure or level anywhere.*

Following out this analogy to fluid motions is very useful in leading to clear views of very many other electrical phenomena, for, although nothing is really explained, an unfamiliar fact seems to us more plausible when we find in it a close analogy to a fact with which we have been long familiar, and about which we have no question. Take the case of the operation of electric motors. We know that an electric motor develops an opposing electromotive force, and every electrician knows that this opposing electromotive force is the secret of the operation of the motor, that mechanical power cannot be developed without it, but I find that few people except those familiar with the theory are willing to believe that this counter electromotive force is of any use. I have known of some motors being constructed with the avowed object of reducing the counter electro-motive force as much as possible, with the idea that it was a hurtful resistance, preventing the motor from developing its full power. But how is it with a fluid flowing through a pipe? In order to make it do work we must construct a machine to produce a counter pressure. A water motor always checks the flow of water.

Take the simple case of a rotary motor. (Rotary motor on blackboard.) Let it run at full speed, and suppose there is no friction. It offers no resistance to the flow of the water. The water flows with the same velocity as though the motor were not there and it does no useful work. Begin now to load the motor, you check its speed and at the same time check the flow of water. As you increase the load you check the flow more and more. The force exerted upon the motor will be greatest when it is brought to rest, and the flow in the pipe stopped; then the water will exert its greatest pressure, but since the motor does not move, it can do no work. Between these two conditions of no power to do work, when moving with the full velocity of the water but without force, and when receiving the full pressure of the water without moving, there must be a condition of maximum power, or maximum rate of working, and we can readily admit that this occurs when the back pressure of the motor is half the *water-moving force*. At this speed half the *water-moving force* is effective in running the motor and half goes to waste in the velocity with which the water leaves the motor. The efficiency of the motor is, therefore, only fifty per cent. It would be far better, if so much power is needed, to use a larger motor and run it at slower speed and at less than its maximum power, and let less of the energy of the water to go to waste.

Now, note the analogy between this and the electric motor. When the electric motor is running it develops a counter electromotive force which corresponds to the back pressure of the water motor. When this counter electromotive force equals half the electromotive force of the generator, the electric motor is giving its maximum power; but it is using only half the energy of the electric current, the other half going to waste in developing heat in the conducting wires leading to the motor, and in the motor itself. Just as with the water motor, it is better to use a larger size electric motor and let it run at such a rate that it will develop a counter electromotive force equal to more than half the electromotive force of the generator, and while developing less than its maximum power perform a work equal to a larger percentage of the energy given to it. The difference between the water motor, which I have taken for an example, and the electric motor, is this, that while the water motor exerts the greatest back pressure when it is stopped, the electric motor exerts the greatest counter electromotive force when it is running at the highest speed. Otherwise, the analogy between the working of the two is very close, and the efficiency of either one of them is exactly the ratio of the back pressure which it exerts to the possible pressure which can be brought to bear upon it.

In bringing this lecture to a close I wish to acknowledge my own obligation to Mr. Ives, who has kindly loaned and operated his lantern for projecting the views on the screen; to J. W. Queen and Co., for the loan of nearly all the apparatus used and exhibited here this evening, and to Mr. C. H. Richardson and Mr. Metzgar, of the firm of Richardson and Metzgar, who have given their services for the whole day, with the resources of their workshop, for the preparation of the apparatus for the experiments. Without their assistance the preparation of the experimental illustrations would have been impossible.

* [This statement, as well as that which it is intended to elucidate, is, we think, open to question.—Ed. *E. E.*]

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

STUDENTS' MEETINGS.

At a meeting of students on January 19, F. H. Webb, Esq., presiding, the report of the committee was read and adopted. The following gentlemen were elected to form a students' committee for 1888:—Messrs. C. G. Lamb, B.Sc., Chas. Priest, J. N. Cooper, R. W. Paul, E. G. Tidd, A. G. Sanders, and John Rance, jun. (hon. sec.). Mr. J. N. Cooper then read a short note upon "An Error due to Refraction in Mirror Galvanometers." A discussion followed, in which Messrs. Paul, Smith, and Lamb took part.

At a students' meeting on the 2nd inst., Prof. J. A. Fleming, D.Sc., in the chair, Mr. C. G. Lamb, B.Sc., opened a discussion upon the recent papers upon Voltmeters. Messrs. Gimingham, Smith, Paul, Bate, Dykes, Cooper, and Dr. Fleming discussed the subject, and after Mr. Lamb's reply the meeting was terminated by thanking Dr. Fleming for presiding.

COMPANIES' MEETINGS.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The half-yearly general meeting of the Anglo-American Telegraph Company (Limited) was held on February 3rd, at Winchester House, Old Broad-street.

The **Right Hon. Viscount Monck** presided, and in moving the adoption of the report observed that there had been a large increase in their traffic, which, however, had not yet become remunerative. The working expenses had been very much the same as they were in the corresponding period of the previous year; but in the general expenses there had been a considerable increase, owing to the repair of the 1869 cable—an event which appeared to him to be so important as almost to mark an epoch in the history of telegraph construction and repairs. It was to be borne in mind that the cable had been 18 years under water. It broke at a depth of 2,750 fathoms, and to be repaired it had had to be lifted from a depth of 2,300 fathoms. That work had been done by their own ship—the "Minia," and great credit was due to Captain Trott and the officers and crew for the ability, energy, and skill which had been displayed by them. They had also had to transfer the shore ends of the cables at Valentia from their original position, where they were subject to abrasion from the roughness of the bottom on which they were laid, to another spot, where they rested more easily, and with less risk of injury. The 1869 cable had been several times under repair, but there were extensive lengths of the cable which had never been stirred or sustained any injury. The faults in the cable mentioned had been effectually removed by Captain Trott, but he regretted to say that since that the cable had again given out in a depth of 1,500 fathoms, and at a distance of 1,000 miles east of the previous break. Their contest in the law courts in Paris with the French Company for leaving the "pool" had been so far settled entirely in the Company's favour, but until the appeal of the French Company had been settled, they could not consider themselves out of the difficulty. A matter of much more importance was the contest which the Company and the associated companies were engaged in with the Commercial Cable Company of America. If, however, there was any moral turpitude in instituting a fighting tariff, they were not the offenders, for the rate was 2s. a word prior to the working of the Commercial Company, who reduced the charge to 1s. 8d., they themselves being, of course, then obliged to adopt that tariff. That was the state of matters 18 months ago, when the Board, after a careful consideration of the case, came to the conclusion that the only policy they could adopt was to reduce the tariff, not for the purpose of fighting, but for the purpose of stimulating traffic, with the object of gaining a large revenue from a low tariff. That object was fully stated by him at the time, and it was accepted by the great body of the shareholders as a wise and proper policy to adopt. He was still of that opinion. He at the same time carefully guarded himself against naming 6d. or any sum as the ultimate point at which the tariff should be fixed. As he had predicted, the adoption of such a policy had made a considerable demand on their patience and forbearance, and he was sure that no one regretted the fact more than his colleagues and himself. Their traffic was now 162 per cent. larger than it was before the 6d. rate was adopted, but, unfortunately, that was not enough to give them a remunerative revenue. For the first year of the 6d. rate the increase in their traffic was very great, but last year the increase was only 12 per cent. Although that might in time grow to a very much larger extent, he was afraid that the trial of their patience meanwhile would be so great that it would reach what was called the straining point. He thought they had tried the 6d. rate to its full extent, and he did not think there was that element of increase in the traffic which promised to render it remunerative to the shareholders. The question was, what were they to do? They had had meetings with representatives of the Commercial Company, but they had led to nothing, it being impossible for them to subscribe to the demands of that company. At the meeting recently of the Direct United States Company, Sir John Pender threw out a hint that there ought to be another conference. He (the speaker) confessed that his experience of the past did not render him very sanguine as to the result which such a conference might bring forth; but if Sir John Pender could induce the other parties who were interested to go into a conference they themselves would not hold back.

The **Marquis of Tweeddale** seconded the resolution.

Mr. Thomas Smith (of York) supported the motion, observing that he regarded the report as a moderately satisfactory one. He considered that the 6d. rate had now had a fair trial, and if the shareholders were satisfied with the present dividend that rate might be continued. He,

however, suggested that it should be reduced to 3d. ("No, no"), believing that that would terminate the war, which, in his opinion, had now arrived at a point when one side must give way. The market value of the investments forming their renewal fund was only £6,000 short of £1,000,000, and their financial position was therefore a very strong one.

Mr. Chester regretted to hear such a proposal as a reduction of the tariff to 3d. a word. In acting as they were now doing they were simply carrying out the policy which they had pursued for the last 15 years. The policy of crushing out opposition had, however, brought no benefit to the shareholders, and had he maintained, simply led to other cables being laid. It was impossible for them to succeed in their claim to have the whole of the cable traffic across the Atlantic. He believed that if the rate were raised to 9d. a word it would pay the company and meet the wants, the growing wants, of the commercial community.

Mr. Wood suggested that 9d. a word might be charged for express messages, and 6d. a word for ordinary messages.

Mr. John Newton said it seemed to him that in the past there had been nothing but a "squaring" of the opponents of the Company, and that as soon as a compromise was made another competing cable was laid. They must adopt a policy of downright fighting rates, and aim at buying up new cables at less than their cost price.

Mr. Jackson complained of the management, and said that the result of what had been done in the past two years had been to give the proprietors a return on their capital of £1. 6s. 3d. per cent. per annum. He was glad to hear what had been said in regard to another conference.

Other gentlemen having addressed the meeting, the **Chairman**, in reply, at the close of the discussion, stated that by the decision in their contest with the French company, the Company had been awarded a gross sum of about £30,000, and 2,000f. a day for every day that the French company adhered to their resolution to abandon the "pool." As, however, he had already said, that decision had been appealed against. The law would not allow them to charge a rate for express messages. He could understand Mr. Jackson's impatience at the result which had been obtained, but not with the management of the Company. The directors had done the best they could, fighting against facts which could not be changed. Mr. Humphreys had said that if the repairs had been paid for out of revenue they could have declared no dividend. That was so, but then the renewal fund had been established for the very purpose for which it had been used during the half-year. In regard to Mr. Seeley's remarks, the cost of the various repairs to the 1869 cable had been about £200,000, which was a long way short of the cost of a new cable. If for no other reasons, he thought it would be worth their while to repair the cable and keep it going as a test of how long a cable would remain effective in the Atlantic. That was the oldest cable working in the Atlantic. The later cables were of much better construction.

The report was adopted, and the retiring directors and auditors were re-elected.

On the motion of **Mr. Jackson**, seconded by **Mr. Stockdale**, a resolution was afterwards passed conveying the thanks of the meeting to Captain Trott and the officers and crew of the steamship "Minia" for the energy and ability displayed by them in connection with the repair of the 1869 cable.

CUBA SUBMARINE TELEGRAPH COMPANY.

The ordinary general meeting of the Cuba Submarine Telegraph Company (Limited) was held on Wednesday at the offices, Old Broad-street.

Mr. Joaquin de Mancha, who presided, stated that the number of messages transmitted had increased in the past half-year, and, compared with the same period of 1886, they had received £1,528 more. Their expenses had been much about the same, but the repairs had been £300 more. They were enabled to make the half-yearly payment for the cable which they contracted for some years ago. That amounted to £1,875, and they had in hand sufficient to pay the preference dividend at the rate of 10 per cent. They also proposed a dividend on the ordinary shares at the rate of 8 per cent. He concluded by moving the adoption of the report.

Mr. Alexander F. Low seconded the motion.

In answer to questions, the **Chairman** stated that the cost of the cable which they were paying for every half-year was £48,000, of which they had paid off £28,000. When the balance was paid the cable would belong to the Company. He thought that the way in which they had arranged to pay for it was better than if they had bought it outright. The contractors agreed to keep a certain sum in the Company's possession in case the cable required to be put in repair. Up to the present time, however, it had worked most creditably to the Messrs. Hooper. On Monday they received a telegram from Mr. Keith stating that the cable had not spoken. Mr. Keith, however, had found out where the fault was, and he believed its repair would not be very expensive. If they were to pay for the cable at once, the security they now had, in the event of its breaking, would disappear. The security in hand was £5,000. He thought it better to continue the existing arrangement.

The motion was adopted, and the dividends were afterwards approved.

PROVISIONAL PATENTS, 1888.

JANUARY 27.

1243. **An improved portable electric lamp.** Harry Lucas, Tom Bowling Lamp Works, Little King-street, and Ernest Edward Vaughton, 94, Trinity-road, Birchfield, both in Birmingham.

1250. **An improved water wheel for driving electric generators, and its combination with, or application to such generators.** Moritz Immisch, 52, Chancery-lane, London.

1254. **Improvements in forming metallic connections with incandescent lamps and holders therefor.** John Spink and Charles Gauzentes, Sunbridge-chambers, Bradford, Yorkshire.

JANUARY 30.

1364. **Electric lighting for railway and other carriages.** Frederick Johnson Martin, 101-2, Wood-street, Cheapside.

1383. **Electric apparatus for use either as an electro-motor or as an electric current meter.** Francois Borel and Emile Paccaud, 68, Fleet-street, London, E.C.

1386. **Improvements in telegraph insulators and appliances for suspending wires on ærial telegraphs.** George Fowler, 100, The Rye, Peckham, Surrey.

JANUARY 31.

1401. **An improved pocket-compasses.** Albert Lloyd, 333, Ladypool-road, Sparkbrook, Birmingham.

1406. **Improvements to and in connection with electric time signals or alarums.** Mary Turton and Samuel Turton, Dudley-road, Tipton.

1461. **Improvements in applying metals to metals by electric action or electric fusion, applicable more especially to obtaining a rough hard surface or a surface of a character other than that of the metal to which the said surface is applied, but applicable, in other cases where metals can be joined to metals by electric action or electric fusion.** Robert Kirk Boyle, 47, Lincoln's Inn-fields, London.

1479. **Improvements in apparatus for indicating and registering payments, especially applicable for indicating and registering payments for the use of telephones.** Alexander MacGregor, 47, Lincoln's Inn-fields, London.

FEBRUARY 1.

1505. **Improvements in the construction of electric brushes for curative purposes.** Mary McMullin, 8, Quality-court, W.C.

1525. **Improvements relating to the distribution of electricity.** Louis Edmond Solignac, 45, Southampton-buildings, London.

FEBRUARY 2.

1536. **Magnetic and electric telephone and telegraph for transmitting and receiving musical vibrations or signals by means of electricity.** James Battye, 15, Cross Park-street, Batley, Yorkshire.

1557. **Improvements in duplex telegraphy.** Frank Jacob, 28, Southampton-buildings, Chancery-lane, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MARCH 10, 1887.

3658. **Improvements in alternating current transformers or induction coils.** Robert Dick and Rankin Kennedy, 96, Buchanan-street, Glasgow.

MARCH 17, 1887.

4070. **Improvements in combined engines and dynamos.** Matthew Henry Phineas Riall Sankey and Peter William Willans, 24, Southampton-buildings, London, W.C.

MARCH 30, 1887.

4781. **Improvements in electric batteries.** The Electrical Power Storage Company (Limited) and Herbert William Butler, 47, Lincoln's Inn-fields, London, W.C.

MARCH 31, 1887.

4809. **Improvements in insulating electrical conductors.** Eugenio Tortora, 55 and 56, Chancery-lane, London.

DECEMBER 28, 1887.

17,837. **Improved means of generating electricity from heat.** Philip Middleton Justice, 55 and 56, Chancery-lane, Middlesex. (Edward G. Acheson, United States.)

DECEMBER 29, 1887.

17,888. **Improvements in and relating to electro-magnetic marine governors.** George Alexander Smith, Gray's Inn-chambers, 20, High Holborn, London, W.C.

DECEMBER 31, 1887.

17,965. **Improved machines for cleaning windows, mirrors, and similar articles by either mechanical or electrical power.** Francis Redmond, 126, Sandford-road, Ranelagh, Dublin.

SPECIFICATIONS PUBLISHED.

1887.

1654. **Closing secondary battery cells.** W. Kingsland. 8d.

2851. **Automatic switch for electrical circuits.** T. Parker. 8d.

3197. **Secondary batteries.** Sir D. L. Salomons and others. 6d.

4478. **Supporting telegraph, &c., wires.** C. Maynard. 8d.

11,448. **Secondary batteries.** J. S. Sellon. 8d.

16,128. **Mechanical telephones.** W. H. Munns (Sunderland and Monjo). 8d.

16,669. **Combined secondary battery and miner's lamp.** M. Bailey and J. Warner. 6d.

16,728. **Incandescent electric lamps.** A. Heintz. 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednes-day-	Dividend.		Name.	Paid.	Price. Wednes-day
3 Jan.	4%	African Direct 4%	100	98 to 100	1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼	25 July	10/0	India Rubber, G. P. & Tel.	10	17½
12 Feb.	2/0	— fully paid	5	4⅜	28 Oct.	12/6	Indo-European	25	39
28 Oct.	7/6	Anglo-American	100	40	16 Nov.	2/6	London Platino-Brazilian...	10	5
28 Oct.	15/0	— Pref.	100	66	16 March ...	5%	Maxim Western...............	1	¼
12 Feb., 85...	5/0	— Def.........................	100	14⅜	15 May	5%	Oriental Telephone	11	⅜
29 Dec.........	3/0	Brazilian Submarine.........	10	11⅞	14 Oct.	4/0	Reuter's	8	8½
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	3½	1⅝
28 July	8/0	Cuba	10	12	28 July	12%	Submarine	100	135
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	97
14 Oct.	1/0	Direct Spanish	9	4¼	14 July	12/0	Telegraph Construction ...	12	39
18 Oct.	5/0	— 10% Pref.	10	9½	1 July	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	8⅞	30 Nov.	5/0	United Telephone	5	13
12 Jan.	2/6	Eastern	10	11½	......	...	West African..................	10	5
12 Jan.	3/0	— 6% Pref.	10	14¾	1 Sept.	5%	— 5% Debs.	100	93
2 Aug.	5%	— 5%, 1899	100	109	29 Dec.........	6/0	West Coast of America ...	10	5 7-16
28 Oct.	4%	— 4% Deb. Stock	100	105	31 Dec.	8%	— 8% Debs.	100	115
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12⅜	14 Oct.	3/9	Western and Brazilian......	15	9
					14 Oct.	3/9	— Preferred	5½	6¼
2 Aug.	6%	— 6% Deb., 1891	100	109	......	...	— Deferred..................	2½	3 1-16
3 Jan.	5%	— 5% Deb., 1900	100	105x	2 Aug.	6%	— 6% A	100	110
2 Nov.	5%	— — 1890	100	102	2 Aug.	6%	— 6% B	100	107
3 Jan.	5%	Eastern & S. African, 1900	100	104½	......	...	West India and Panama ...	10	1
12 Jan.	5/9	German Union	10	9¾	30 Nov.	...	— 6% 1st Pref.	10	9 15-16
14 Oct.	0/6	Globe Telegraph Trust......	10	5⅜x	13 May, '80...	...	— 6% 2nd Pref.	10	6½
14 Oct.	3/0	— 6% Pref.	10	13½	2 Nov.	7%	West Union of U.S.	$1,000	125
3 Jan.	5/0	Great Northern...............	10	14x	1 Sept.	6%	— 6% Sterling	100	105

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Dec. ...	£38,908	– £1,631
Brazilian Submarine	F. Jan. 20 ...	£6,902	...	Great Northern	M. of Dec. ...	21,600	...
Cuba Submarine	M. of Dec. ...	3,300	+ £175	Submarine	None	Published.	
Direct Spanish.....................	M. of Jan. ...	1,943	+ 39	West Coast of America	M. of Jan. ...	4,800	...
— United States	None	Published.	...	Western and Brazilian	W. Jan. 20 ...	1,722	...
Eastern..............................	M. of Dec. ...	57,703	+ 4,880	West India and Panama	F. Jan. 15......	2,509	– 467

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

West Coast of America Company.—The traffic receipts of the West Coast of America Telegraph Company for January were £4,800.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the past week amounted to £3,142.

Direct Spanish Company.—The traffic receipts of the Direct Spanish Company for January were £1,943, against £1,904 for the corresponding period of last year.

Great Northern Company.—The traffic receipts of the Great Northern Telegraph Company for January were £21,400, against £20,400 and £19,880 for the corresponding months of 1887 and 1886 respectively.

Western and Brazilian Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the week ending January 27, after deducting the "fifth" of the gross receipts payable to the London Platino Brazilian Company, were £1,764.

The Electrical Automatic Delivery Box Company.—This company is formed with a capital of £60,000 to acquire the patent and exclusive rights for the United Kingdom of Great Britain and Ireland of the Electrical Automatic Delivery Box, and the patent rights for India, New Zealand, Victoria, and Cape of Good Hope, invented by Messrs. Frank Villiers-Stead and Co. The cost, it is said, to erect a machine to deliver four articles will be about one-half the cost of machines now used. The possibility of the electrical automatic box being worked by false coin, wire, and shot is infinitesimal, whereas it is well known, in the other machines now before the public, frauds occur daily. It is stated that large orders have already been received to manufacture boxes for the Continent. The purchase price is £30,000, of which the vendor takes £20,000 in fully paid shares.

Submarine Telegraph Company.—The report of the directors of the Submarine Telegraph Company for the six months ending December 31, 1887, shows a net result which enables the directors to add the usual proportion of the receipts to the reserve fund, to recommend a dividend at the rate of 15½ per cent. per annum, and to carry over a balance of £209 to the next account. The same dividend was paid in the corresponding period of 1886. The number of messages transmitted in the six months was 1,695,860, against 1,691,280 in 1886; but the length of the messages was only 11·03 words against 11·11 words. The Board has long been endeavouring to obtain a renewal of the French concession, and on three occasions within the last two years they have had strong grounds for believing that those efforts would be crowned with success. Unfortunately, the English Government have changed their policy, and propose to take into their own hands, at the expiration of the Company's French and Belgian concessions in January, 1889, the working of telegraphic communication with Holland, Germany, Belgium, and France. This change of policy was communicated to the Board in a letter addressed to the chairman of the Company by the Chancellor of the Exchequer early in November, and the arrangements about to be concluded in Paris were thus frustrated. The Postmaster-General has since that time informed the directors that Her Majesty's Government have decided not to grant any extension of the company's license for landing cables on the shores of this country, or to sanction a continuance of the working arrangement between the Company and the Post Office, as defined by the agreement of July 11, 1868, beyond the date fixed by that agreement. The Belgian Minister of Posts and Telegraphs has also informed the directors that it has been decided not to renew the concession granted to the company for landing cables on the Belgian shore. In these circumstances negotiations are being carried on between Her Majesty's Government and the Board, and when these negotiations are terminated the result will be made known to the shareholders without delay.

NOTES.

Halifax.—Attempts have been made to play a football match under the electric light, but the arrangements failed, and the match has been abandoned.

The Cruto Lamp.—According to *La Lumière Electrique* the French patent for the Cruto incandescence lamp has been purchased by the firm of Rothschild.

Electric Lighting Act.—Lord Thurlow has re-introduced in the House of Peers his Bill of last session for amending the Electric Lighting Act, 1882.

Society of Telegraph Engineers.—The paper to be read on Thursday, Feb. 23, is "On the present state of Fire Telegraphy," by R. von Fischer Treuenfeld.

Accumulators.—The Electrical Accumulator and Lighting Company, of Detroit, Michigan, have now nearly 1,000 lights in connection with their storage batteries.

Great Northern Railway.—At the half-yearly general meeting of this Company, held at King's Cross Station on Wednesday, the proprietors were asked to sanction an expenditure of £520 for further electric lighting of carriages.

Aluminium.—According to the *Western Electrician*, M. Camille Faure claims that the Cowles process for obtaining aluminium is his own invention, patented so far back as 1883. He has, it is said, taken steps to work the invention in question.

Preston.—In the notice of the proposed lease of tramways, the Corporation of the borough of Preston have inserted the following clause:—"That the lessees are not to use any motive power other than animal power without the consent of the Corporation."

Windsor.—An electric light installation is being erected at Baron Schroder's country house by Messrs. Drake and Gorham. Two gas engines will be employed to drive the Elwell-Parker improved type dynamos suitably wound for charging 106 of Drake and Gorham's accumulators.

British Telegraph Wire.—The value of the telegraph wire exported from England during 1887 is estimated by *Electricité* at 20,427,425fr., as against 24,816,675fr. in 1886. A decree has been published by the *Mexican Official Journal* allowing telegraph and telephone wire to be imported free of duty.

Lighting in the Temple.—The electrical committee of the Inner Temple is canvassing the tenants of that Inn with the view of ascertaining how many of them wish to have their chambers supplied with the electric light. It is calculated by the committee that if the demand be sufficient the expense would not exceed that of gas.

New Cable.—According to the *Times* of yesterday, news has been received at Paris that the cable between Curacoa and Venezuela has been laid. A vessel is laying the cable between Curacoa and San Domingo, and will reach the latter country in two days, thus connecting San Domingo with Europe and with the United States.

Electricity and Gunnery.—An unexpected test of the 12-inch breech-loading 45 ton gun on the sea face of the Horse Sand Fort at Spithead was made a few days ago. The gun was fired by electricity, the necessary arrangements for which were carried out by Master-Gunner Wixen. Three rounds were fired with perfectly satisfactory results.

The Brighton Railway.—From a report of the first annual meeting of the Ridsdale Lamp Company we gather that the Brighton Company is going to adopt their lamp, with the exception of those trains which are lighted by means of electricity. Of course, we should prefer to have seen the electric lighting extended. No doubt this will come in good time.

Buckingham.—The local authorities have given permission to Mr. A. C. Rogers to carry overhead wires across the highway for electric lighting purposes in the borough. Such permission has hitherto been refused because the applications were from companies outside the borough; but, as Councillor J. T. Harrison remarked, this differed in that it was from a townsman.

Maxim-Weston System.—It is understood that the Commissioners of Sewers have received an offer from this company for the lighting of the whole of the City by electricity. This information reached us too late to be dealt with in our leader, but we may take this opportunity of reiterating the moral of the leader that companies which interfere and do not initiate had better cease to exist.

Royal Institution.—Last Friday, at the Royal Institution, Mr. W. H. Preece, F.R.S., read a paper on "Safety Lamps in Collieries." The colliers of the future will have much to thank Mr. Preece for when the public mind has been fully aroused to the necessity of obtaining better and safer mining lamps. Mr. Preece has been indefatigable in testifying to the value of electricity as an agent for supplying a safe light in collieries.

A Long-Lived Lamp.—The ordinary guarantee of life for Edison's incandescent electric lamps is 600 hours, but one lamp in the *Globe* office has just gone out after a most extraordinary life. It was put in about the end of November, 1884, when the Edison system was installed in the office. It has continued burning ever since on the average 5¼ hours every day, six days a week, making a total life of 5,292 hours.—*Toronto Globe.*

Glasgow Exhibition.—The united candle power nominal of the electric light to be used at this exhibition is equal to 1,090,000 candles, and the motor power will be produced by engines of 1,200 horse power. It is expected, as at Kensington, that the great attraction outside will be the Fairy Fountain, which, with its numerous jets, will be illuminated by electricity. The centre jet will throw water to a height of about 120 feet, and there will be about 100 jets altogether.

Draughts Playing by Telegraph.—A match is to played by telegraph on the 2nd prox. between six of the members of the Melbourne Draughts Club and six representatives of South Australia. The similar fixture of a year ago fell through, owing to difficulties which need not be particularised; but it is confidently anticipated that the present match will be played. It is understood that owing to the pressure of business engagements, Mr. James Paterson will very probably be unable to play for Melbourne.—*Australasian.*

Earth Currents.—With a view to carry into effect the recommendation of the International Congress of Electricians at their Paris meeting in 1881, the Spanish Government is constructing two overhead lines entirely independent of the telegraph wires, and exclusively devoted to the investigation of the phenomena of earth currents. These lines will each be about five miles in length, one being parallel and the other at right-angles to the magnetic meridian.

The intersection of the two lines will be at the astronomical observatory of San-Fernando.

Military Search-light.—According to *l'Electricien*, a system of electric illumination for fortresses has been adopted by the German military authorities. The intensity of the light is sufficient to illuminate objects within a radius of 12 kilometres. The apparatus, of which the details are kept a strict secret, though the essential novelty is stated to be in the use of parabolic mirrors, is constructed by Schuckert and Co., of Nürnberg. All the fortresses on the banks of the Rhine are to be immediately provided with the search-light in question.

Brussels Electric Tramway.—The Julien accumulator appears to be giving very satisfactory results on the Brussels tramway. The total weight of each car, with its accumulators and its full complement of passengers, is 6,100 kilos; the weight of the batteries is 1,500 kilos.; and the run, without changing the accumulators, is 48 kilometers, which, according to the Report of the Congress of Tramway Companies, might be increased to 55 kilometers. Two sets of accumulators are employed for each car; one being re-charged whilst the other is in use.

The Electric Light in Spain.—The contract for the lighting of the boulevards at Barcelona was recently submitted to public tender. Only one firm, however, the *Sociedad Espanola de Electricidad*, came forward, its tender being accepted. The directors of the Commercial Union Circle, of Madid, have applied for tenders for the installation of the electric light at their *hôtel*. This is to comprise three arc lamps and from 160 to 200 incandescence lamps, with machinery to be located in a detached building. The contract will remain open until the 1st of March next.

Electric Light in a Glasgow Theatre.—Taking the lead in the west, the lessees of the Royalty Theatre Glasgow, some time ago decided to introduce the electric light for stage purposes. With this in view, an order was given to the Anglo-American Brush Light Company, and during the past week, under the supervision of Prof. Sir William Thomson, the work of construction was carried out. The light has not only been fitted up for stage uses, but it has also replaced the gas in every part of the auditorium and the accesses. The entire installation consists of over 300 lights.

An Electric Club.—The New York Electric Club was recently opened with considerable *éclat* at 17, East Twenty-second-street; on which occasion the members and visitors had the opportunity of listening to an address by Prof. Rowland, on "The Electrical and Magnetic Discoveries of Faraday." A letter was received from Prof. Sir W. Thomson, expressing his earnest wishes for the prosperity of the club, and his regret at being unable to hear his friend Prof. Rowland. The president is Mr. Henry C. Davis, and Messrs. G. W. Hebard, Thos. A. Edison, J. B. Powell, and G. L. Beetle, are vice-presidents.

The Electric Top.—This scientific toy, described by *La Nature*, is constructed of a disc of soft iron, mounted on a central "peg." When revolving with a certain velocity, the disc is repelled by the poles of a magnet; under other conditions, it is, of course, attracted. It is said to illustrate the production of induced currents in conductors moving in a magnetic field. It appears to us that this may be illustrated by the rapid diminution of the velocity of rotation; but that the *repulsion* illustrates more especially a preponderating effect of the inverse current induced in those portions of the conductor which are approaching the magnet over that of the direct current induced in the metal moving from the poles.

The Khotinski Lamp.—The incandescence lamp of a Russian inventor, M. de Khotinski, manufactured by him at Rotterdam, has for some months passed been introduced in France, being employed for several installations in Paris, notably those at the *Nouveau Cirque* and at the *Banque de France*. This lamp, of which the mode of manufacture is kept a profound secret, has, according to the *Bulletin International de l'Electricité*, a filament which is obtained from an American vegetable product, treated chemically prior to being subjected to a high temperature, and which is possessed of great homogeneousness. The lamp, however, does not appear to possess any very special qualities of duration or economy, its consumption per candle-power being 3·5 watts when an average life of 1,000 hours is required.

A New Metre.—According to the system of measurement which M. Freycinet is seeking to introduce, in substitution for the C.G.S. system, the unit of length or metre is the acceleration produced by gravity in 1sec. in a body falling freely, *i.e.*, in *vacuo*, in the latitude of Paris. It would therefore be equal to 9·8 of the present metres. The unit of volume would be somewhat less than the *litre*, viz.: a cube of which the side measures $\frac{1}{100}$ of the new metre. We apprehend, and we must also say we hope, that the new system will not find favour amongst electricians. The unanimous adoption of the C.G.S. system by the International Congress of Electricians, under the presidency of M. Dumas, in September, 1881, may, we think, be regarded as final—at least for the next quarter of a century—supported as it is by the names of Sir W. Thomson in England, and of Helmholtz in Germany.

Weston-super-Mare.—According to a local paper, we learn that owing to the damaging statements made by Alderman Bruford and other shareholders in the Taunton Gas Company respecting the reliability of the electric light in that town, members of the Local Board and other gentlemen, who are desirous of seeing the electric light introduced into Weston, have privately visited Taunton upon several occasions during the past few weeks, to test the accuracy of Mr. Bruford's statements, with the result that they are unanimously of opinion that there is no justification for such statements, the light upon each occasion being in every respect equal to what it was when the deputation visited Taunton on November 18th, 1887. It has now been definitely decided to use only the system adopted in Taunton (the Thomson-Houston), in the event of the electric light being introduced into Weston-super-Mare.

"I Told You so."—We all know the story of the woman whose incessant remark was "I told you so," being made to say when her husband stated the brindle cow had swallowed the grindstone, "I told you so." The London correspondents of country papers fall into another error and "believe so" in every long drawn tale they hear about electricity. The correspondent generally writes: "I hear that Mr. So-and-so, a painter, or a tinker with an inherent tendency to dabble in electricity and mechanics, has made a startingly simple discovery of an electrical application to cycles and bicycles, &c., and has sold the patent for £50,000." Happy man; though it would have been just as wise to have said £100,000 while about it. Why will not these absorptive correspondents imbibe a little of the most elementary information upon matters electrical, and they would then know that £50,000 was about as likely to be

paid just now for an electrical patent as a tunnel is to be made to the Antipodes.

Brooklyn.—The tenders for lighting the Brooklyn streets during 1888 show that the Citizens' Electric Company were charged 182.50dols. per lamp per year, the Municipal Electrical Electric Light Company the same sum, the Citizens', Metropolitan, People's and Nassau Gas Companies 22dols. per light per year. The Williamsburgh Gas Company charges 21.75dols., the Brooklyn 19.80. These prices are the same as last year, and under them it cost the city for lighting 388,925dols. The amount to be spent during the next year, or, rather the current year, is 480,000dols., and there is a balance in hand of 20,000dols., with which the electric light is going to be extended. The two electric companies, one in the Eastern district and the other in the Western, have offered to supply the city at 50 cents per night for each light, but the price is fixed at 30 cents per night for each light of 1,200 candle-power, and 40 cents per night for each light of 2,000 candle-power.

Brussels Exhibition.—Great dissatisfaction prevails amongst Belgian electric lighting firms by reason of the alleged action of the Executive Committee in placing the lighting of the exhibition buildings in the hands of foreign companies. This dissatisfaction has been shown by the abstention of the firms in question from any participation in the undertaking. In a letter addressed to Count d'Oultremont by "The Members of Committee 47"—that for Electricity and its Applications—the writers say:—"We have observed with great surprise that, with the exception of the *Société Industrielle d'Electricité*, no Belgian electric lighting firm has sent in any application for space." Finally, they request the Count to intervene in the matter, and to request the Executive Committee to adopt such measures as may allow of the Belgian electric lighting companies being represented in a manner befitting the importance that this industry has obtained in the country, and the continuous progress that is being achieved in it.

Lighting of a Yacht.—The steam yacht "Victoria" (Capt. Lewisham, late of the "Ceylon"), which sailed from Gravesend on the 4th inst. for a pleasure cruise of three months in the Mediterranean, has just been fitted with a new electric light plant by Messrs. Browett, Lindley, and Co., of Manchester. The plant consists of 150 incandescent lamps, and an F2 "Victoria" brush dynamo, driven direct at 200 revolutions by a new type of vertical tandem compound engine, recently patented by the above firm. The installation of the generating plant presented some difficulties, as the whole had to be carried on a wrot-iron platform erected for the purpose in a corner of the main engine room, and level with the top of the cylinders. The whole plant is very compact and entirely self-contained, and the engine is constructed to work either as a high pressure engine with 50lb. steam from the donkey boilers and exhausting into the air for use when in port, or to work compound with steam from the main boilers, which carry 80lb. pressure and exhausting into the main condensers.

Physical Society, Glasgow University.—An ordinary meeting of this society was held on Friday night, the 10th inst., Mr. Maclean, Pres., in the chair. Mr. Thomas Gray, B.Sc., exhibited and described an improved apparatus for the determination of the intensity of the horizontal component of the earth's magnetic field. In this apparatus a magnetometer consisting of a small magnetic needle about 1cm. in length, mounted in a light aluminium frame carrying a small mirror suspended in a vertical glass tube fixed to a wooden base plate, is supported on a light but rigid wooden frame which is capable of turning round a vertical axis. Two deflector magnets mounted on suitable stands are carried by a strip of thick glass, which turns round the same vertical axis in such a way that the deflectors are always on opposite sides and at equal distances from the magnetometer needle. The method is in principle the same as that of Gauss, and the apparatus is a more perfect form of that described by Mr. Gray in the *Phil. Mag.* for December, 1885; the *sine* method being adopted in this case instead of the *tangent* method as described in the paper just referred to.

Anglo-American Brush Company—At the invitation of the directors of the Anglo-American Brush Electric Light Corporation, a party of gentlemen, including several members of the Commission of Sewers, on Saturday paid a visit to the works in the Belvedere-road, Lambeth. The guests were taken through the works and the various apparatus explained. Special attention was called to the Callender and Webber patent for laying down mains, by which a separate channel is provided for each cable. The passage is impervious to water or gas—indeed, at the works can now be seen a segment which is still practically as good as ever, although it has undergone the severe test of being covered with water and generally "misused" for a period of two years. By this system, moreover, the cables can be seen to and repaired, if need be, without the inconveniences necessarily entailed by the breaking up of a roadway. All the accessories of electric lighting used by the Brush Company are manufactured on the premises, giving employment to about 300 hands—men, women, and boys, the two latter finding employment in the glass-blowing and incandescent lamp departments.

M. Lucien Gaulard.—It is with sadness and sincere regret that we have to refer to the mental illness of this well-known electrician. We read in a French paper that on Saturday night a well-dressed man rang at the gates of the Elysée and ordered the *suisse* to show him immediately into the presence of the President of the Republic, as he had a communication to make to him which would admit of no delay. On being questioned, his condition became evident, as he asserted that he was the Supreme Being and would brook no delay. He was taken to the station at the *Rue d'Anjou*, where he passed the night. On the following morning he was sent by the Commissary of Police to the infirmary of the *depôt*, where he was examined by the celebrated *aliéniste*, Dr. Garnier. The impression previously produced as to his mental condition being fully confirmed by his extraordinary ravings and by an incipient general paralysis, it was decided to send him to the hospital of Sainte-Anne. M. Gaulard, who is best known by his work in connection with secondary transformers, but who is also the author of other important works, obtained the prize of 10,000f. at the Turin Electrical Exhibition, and was created by King Humbert Chevalier of the Order of Saints Maurice and Lazare.

Bradford Telephone Exchange.—The subscribers to the Telephone Exchange, invited by the National Telephone Company, Limited, had a private view of the new switch-room and switch-boards which were opened for use on Thursday. The system adopted is that patented by the Western Electric Company, of Chicago, and is known as the "multiple system." Its leading characteristic is that the wires are so arranged by an ingenious system of duplication that each operator has under her control not

only, as hitherto, the wires for which she herself is responsible, but also all the other wires connected to the Exchange. By the old method each operator had under her control fifty wires. Should any one of these fifty wires wish to communicate with one in a set in charge of another operator, it became necessary for the one operator to speak across the room to the other to make known the number wanted, and then the connection was made by means of trunk wires connecting the two sets. This system, whilst suitable for a small exchange, has been found quite inadequate to cope with the amount of business which now passes through the larger Exchanges. According to the new plan, each operator has arranged before her in blocks of 100, the whole of the 500 lines now connected to the switch room. It is only then necessary for the operator called to connect her telephone to the line of any subscriber asked for, to ascertain if it is at liberty, and if so to at once make the connection. It is obvious that a great saving of time must thus ensue. The multiple system has hitherto only been adopted in the London, Liverpool, and Glasgow Telephonic Exchanges.

Atlantic Cables.—The *Financial News*, writing on this subject, says:—"Like the southern railways, all the Atlantic cable companies are avowedly anxious for peace. The only thing they desire more is a remunerative tariff, and that is what they have greatest difficulty in agreeing about. Each company seems to have its own idea of what the new rate should be. The Anglo-American is in favour of a shilling tariff, Sir John Pender being of opinion that it would yield results very satisfactory to his shareholders. The Direct Cable Company would also prefer the shilling scale, at least as an experiment. Strange to say, the advocates of higher rates are to be found among the younger companies which came into existence in order to confer on us the blessings of cheap telegraphy. Mr. Jay Gould has signified his readiness to join in a general advance, but he has doubts about the efficacy of a shilling rate. His cables were so characteristically financed that they require a very large income to yield even a nominal return to their watered capital. Their actual cost to him was about 7,000,000dols.; he capitalised them at 14,000,000dols., and then leased them to the Western Union Company for fifty years on a guarantee of five per cent. per annum. The Western Union Company should therefore clear 700,000dols. per annum in order to avoid loss on its guarantee. At the sixpenny rate it must of course have been losing heavily, and Mr. Gould seems to be doubtful if even a shilling per word could enable it to cover its guarantee. So far as he is concerned there is no thought of less than a shilling per word being tried." With regard to the breakdown in the negotiations with Mr. Mackay the news requires a good deal of supplementary matter added to its explanation to make it even approximately correct.

Electric Lighting of the City Streets.—At a special meetings of the Commissioners of Sewers, held at the Guildhall on Tuesday afternoon, under the chairmanship of Mr. W. H. Pannell, the Streets Committee submitted an amended report on the proposed contract between the Anglo-American Brush Electric Light Corporation and the Commissioners, in which it was stated that the committee had further considered the proposed arrangement with the Corporation, and that General Webber, the chairman of the Company, had agreed to deposit £1,000 to be forfeited in the event of the Company not commencing their work within six months from the signing of the contract, or not completing the installation by October, 1889; and that in the event of the Commissioners seeing reason to terminate the contract for public lighting within seven years, the Company's exclusive right of way for private lighting should then cease. Mr. J. C. Bell (chairman of the Streets Committee) said he was prepared to at once go into the question. It seemed ridiculous to keep on adjourning so important a question from month to month, and he asked the court to bear in mind that unless the Company were permitted to at once commence their works, the lighting of the City by means of the electric light would not be accomplished by the winter of 1889, but would be thrown back until 1890. The Remembrancer, Mr. G. Prior Goldney, stated that it was of the most vital importance that some action should be taken with respect to the provisional order now before the Board of Trade at the instance of the South Metropolitan Electric Supply Association, as that association was seeking powers to light a portion of the west-end of the City, that being part of the area embraced in the contract proposed to be entered into with the Brush Company. Mr. Bell remarked that, after hearing what the Remembrancer had said, there was every reason for having the question decided at once, and for that purpose he would move that the matter of the electric lighting of the City be put on the paper of business for discussion at the commencement of the business of the court next Tuesday. This was agreed to.

Electric Boat.—We are informed by *Electricité* that a ship s boat or cutter, the motive power for which is supplied by accumulators, has just been constructed by the *Société des Forges et Chantiers de la Méditerranée* under the orders of the French Admiralty. The preliminary trials of this vessel made at Hâvre were, according to the reports published, entirely successful, and it has been assigned to the military port of Brest, there to be employed in ordinary work, in order that its behaviour and capabilities may be thoroughly studied. The boat in question is of the same dimensions as the steam cutters (*canots à vapeur*) hitherto built for the French marine, *i.e.*, 8·85 metres in length, 2·25m. in breadth, and 1·54m. in depth. The latter vessels are of very heavy build, being intended for work in rough as well as in fine weather. Their speed is six knots an hour, which they are capable of maintaining during four hours with the quantity of coal and water that can be stored in them. The conditions laid down for the construction of the new vessel were that the regulation steam motor should be replaced weight for weight by an electric motor, and that the speed attainable by steam should be maintained for at least six, instead of four, hours. These conditions have been almost exactly carried into effect, although the weight of the electrical apparatus is slightly greater than that of the steam motor and its accessories. These, comprising the engine, the boiler, coal and water-tank, together weigh 2,850 kilos.; whilst the electrical material necessary to obtain the propulsion during the required period, and consisting of the dynamo, the motor and reversing apparatus and the accumulators, weighs 2,891 kilos. Taking into account the great advantage of being able to continue the propulsion during six instead of four hours, the experiments at Hâvre must be regarded as being altogether in favour of the new vessel. The electric motor, constructed under the best conditions as regards lightness, was devised by Capt. Krebs, well-known through his experiments in military aerostation; it is provided with an apparatus to allow of the movement being rapidly reversed without shock. The

accumulators are on the Commelin-Desmazure system, and are composed of 132 couples, so arranged as to allow of the regulation of the speed by means of a commutator. This application of electricity, which is by no means a novel one, but which has not until recently been carried out in a practical form, would no doubt receive a rapid extension if the ratio of weight to power in secondary batteries could be considerably reduced.

The Meteorological Society.—At the meeting of this society on Wednesday the Hon. R. Abercromby read a paper on "Electrical and Meteorological Observations on the Peak of Teneriffe." The following are the author's remarks on the electrical portion of these observations:—All over the world the normal condition of the atmosphere has been found to be that of a greater or less positive potential between a point above the earth and the surface of the ground itself. The only notable exception to this law was found in some observations made on the Peak of Teneriffe in the year 1856 with a gold-leaf electrometer. Then it was noted that the condition of the Peak was constantly resinous or negative. Fifteen sets of observations were made—nine at Puerto d'Orotava, 50ft. above sea level, and six at various altitudes up to 12,200ft. Each set usually consisted of three series of — earth, air, earth — determinations. The height of the fuze may be taken at 5ft. 5in. Every observation showed positive electricity of variable potential. One of the Orotava sets had to be discarded. The mean of the remaining eight gave a positive potential of 138 volts; the highest being 193, the lowest 98 volts. One day, when an ascent was made to the rock of Gayga, an observation on the slope of the mountain at 3,800ft. gave a potential of 99 volts, while on the rock itself, 7,100ft., tension rose to 257 volts. Electrometer observations, Rock of Gayga (7,100ft.), October 20th, 1887, 12.50 p.m:—

Earth	7·49	7·43	7·15
Air	5·96	6·15	6·17
Earth	7·43	7·33	7·45

The figures give the readings of the screw, not the potentials in volts, but the $\frac{1}{100}$th turn of the screw was practically equal to a difference in tension of 2 volts. A few days later the Peak was ascended. At 5,600ft. on the slope of the mountain the potential was 111 volts. On the top of the Peak, 12,200ft., the potential rose to no less than 549 volts. This was at 8 a.m. of October 24th. The wind was blowing at the rate of about ten miles an hour from the north-east, and was doubtless the north-east trade. No upper clouds were visible. The dry and wet bulbs marked 31deg. and 26deg. respectively. There was a little white frost on the ground—pumice dust, sulphur, and whitened lava—and the earth readings were remarkably accordant, only differing by the $\frac{1}{100}$th of a turn of the screw. One day at Orotava there was very heavy rain, and negative indications might possibly have been obtained; but the author did not think it expedient to let the electrometer be drenched. The results of all the observations point unmistakably to the conclusion that during the month of October the electrical conditions of the peak of Teneriffe were the same as in every other part of the world. The potential was moderately positive at the same distance from the ground even at considerable altitudes, but the tension rose enormously round a sharp point, and a projecting edge of rock.

Factory Lighting.—Messrs. James Paterson and Co. have just had built a new factory at Dundee, called the Lawside Factory, for the manufacture of jute. The main factory is 260ft. long by 132ft. broad. Adjoining this, but partitioned off by a main wall with sliding iron doors, are the finishing and forwarding departments, having a floorage space of 150ft. in length, by 90ft. in breadth. This factory will be lighted entirely by electricity, and it is the largest work in Dundee so lighted. A Mather and Platt dynamo is used, of the Manchester type, No. 6A size, compound wound for an output of 100 volts, 330 amperes at a speed of 900 revolutions per minute. The resistance of the shunt coils is 18 ohms, and of the series coils 0·0045 ohms, and of the armature 0·01 ohm, the total electrical efficiency being 94 per cent. The machine is fitted with copper commutator insulated with mica, and has three brushes on each rocking arm, each separately adjustible with spring forward thrust and hold-off catch. The dynamo is driven by the main factory engine from the second shafts, and generates the current necessary for 423 Edison-Swan lamps of 16, and a few of 8, 32, and 50 candle-power at present installed, but is sufficiently large to supply 550 lights. The current is controlled by a five-way switch placed in the dynamo, the five main departments being the factory, finishing department, handloom shop, engine room, and offices. The offices are lighted by 52 lamps controlled by an eight-way switch, so that any of the rooms may be lighted at pleasure. Each narrow loom is lighted by one of the lamps, the wider looms having two. Safety fuses are used throughout the installation. The wires are insulated, and besides are enclosed in a wooden casing so as to prevent, as far as possible, any damage arising. Provision is made against any accident to the new illuminant by nine Bower lamps placed at various points throughout the works, so that in case of the engine having to be stopped from any cause the gas lamps can be turned on in a moment. The electrical engineers who have carried out this work are Messrs. Lowdon Bros., and it has been carried out under the superintendence of Professor Ewing, who wrote out the specification, and has acted throughout as consulting engineer for the installation. The factory is a model one in many respects, and the firm has spared neither pains nor cost to provide a building in which they shall be able to carry out the work in the best possible manner. On Saturday night last the employés at the Lawside and Heathfield Works were entertained to tea and a dance by Messrs. Longair and Couper, to the number of about 800, in the yarn loft, which was decorated for the occasion. Whilst the party were assembling the loft was lighted by gas only; but after the guests had taken their seats the electric light flashed out from a large number of lamps hung from the roof, and instantly there was a brilliant illumination of the large room. A hearty cheer from the people showed their appreciation of the new light. In the course of the evening Mr. Longair, who, with Mr. Couper, are the partners of the firm, stated that they had tried to make the new works, with respect to ventilation and heating, as comfortable and healthy as possible; and with regard to electric lighting they had improved vastly on the present system. He thought that with certain precautions the electric light would certainly be the light of the future, as was evidenced by the brilliant effects produced in the works that evening. There is no doubt, we think, that the conclusions of Mr. Longair are correct, and that it only requires care and attention on the part of electric light engineers to vastly increase the business that is being done in the lighting of all kinds of factories.

CONSTANT PRESSURE IN ELECTRIC TOWN MAINS.

III.

Before entering upon the question of regulating the pressure by resistances, which is the third method mentioned in our last article, it may be useful to briefly recapitulate the investigation as far as it has been carried in our two previous articles. We showed, in the first place, that the variation of 5 per cent. in the pressure up and down from the standard, as contemplated originally in the Board of Trade Rules, is inadmissible, and that $1\frac{1}{2}$ per cent. would probably be found a practical working limit by which the size of mains must be determined. We then dealt with the economic conditions regulating the size of feeders as dependent upon the permissible loss of pressure, which, by way of example, we took at 20 volts. The next step in our investigation was to show how an increase in the number of feeders produces economy in copper, but that in that case the pressure on each feeder must be under independent control. The device of using lamps of different voltage we found to be impracticable, and we also found that the pressure on each feeding centre must be at all times kept at 101·5 volts if the lamps are of 100 volts. The difficulties of, and objections to, using an independent dynamo for each feeder, and those of using a number of main dynamos, and small regulating dynamos for the feeders, we found to be so great as to preclude either system from practical use, leaving available only the method of regulating by resistances, which we shall now examine in detail.

For reasons already stated, the resistance to be put in each feeder must be equally divided between the outgoing and incoming branch, and the pressure to be kept on the main bars at the station must evidently be at least as high as that required for the feeder which is most heavily loaded. The resistance on this feeder would then be completely cut out, and the resistances on the other feeders would be adjusted inversely to the current each has to carry. Let c_1, c_2, c_3, &c., represent the currents in the first, second, third, and the other feeders, r_1, r_2, r_3, &c., their resistances, and ρ_1, ρ_2, ρ_3, &c., the resistances of their respective rheostats; then the following formulæ express the condition of regulation :—

$$p = 101{\cdot}5 + c_1(r_1 + \rho_1)$$
$$= 101{\cdot}5 + c_2(r_2 + \rho_2)$$
$$= 101{\cdot}5 + c_3(r_3 + \rho_3).$$

If the first feeder is the one most heavily loaded, we reduce ρ_1 to zero, and have the pressure on the main bars,

$$p = 101{\cdot}5 + c_1 r_1.$$

The resistance to be inserted into the second feeder is found from the formula—

$$c_1 r_1 = c_2(r_2 + \rho_2);$$

giving $$\rho_2 = r_1 \frac{c_1}{c_2} - r_2.$$

The smaller c_2, the current in the second feeder, as compared to c_1, the current in the first feeder, the larger must be the artificial resistance ρ_2 to be inserted in the second feeder. If no current at all is required in the second feeder—that is to say, if all the lamps ordinarily supplied from that feeding centre are switched out—the ratio $\frac{c_1}{c_2}$ becomes infinite, and the resistance ρ_2 must also be made infinite—that is to say, the connection of the second feeder with the main bars must be completely broken. There is no difficulty in doing this; but what happens if, instead of all the lamps on the second feeder being switched off, a few are left on? In this case the ratio $\frac{c_1}{c_2}$, although not infinite, is very large, and would require ρ_2 to be also very large. Now, artificial resistance coils, or rheostats, capable of carrying heavy currents, are always somewhat cumbersome; but when their resistance is required to be very high they become almost unwieldy, and the question arises whether our expedient of regulating the pressure by means of these rheostats is, after all, a practicable one, considering the large range of resistance required for each rheostat. To answer this question we must find out what is the smallest range of resistance we can do with in each rheostat. The range naturally depends upon the more or less even use of light throughout the district, being greatest when the change in the density of lighting on neighbouring portions of the network is most abrupt. To obtain the limits we must, therefore, investigate some of the worst possible cases of unequal distribution. One of these cases is evidently when all the lights are on in the neighbourhood of alternate feeding centres, and no lights are on in the neighbourhood of the intermediate feeding centres. Another case is when the full demand and no demand alternate in neighbouring districts, each supplied by 2, 3, or more feeders. The first case is in its simplest form graphically represented by Fig. 1, where N N represents the network main (shown

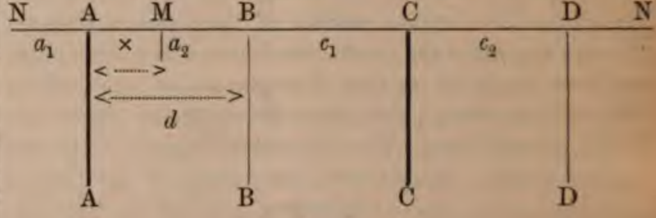


FIG. 1.

by a single line, although in reality consisting of a pair of cables), and A B C D are the feeders; those shown in thick lines being supposed to serve the districts where the demand is at its maximum. We suppose all the lamps between a_1 and a_2 to be alight, all the lamps between a_2 and c_1 to be extinguished; and, again, all the lamps between c_1 and c_2 to be alight. For the sake of simplicity, we assume that the feeding centres are equidistant, and that all the feeders supply equal current when the demand is uniform. The problem is to find how much current flows through each feeder when the demand is uneven, as above explained. If the feeders B and D were disconnected, no current would flow in the portions of the main comprised between the points Dc_2, Ba_2, and Bc_1, and the pressure at the points a_2, c_1, and c_2 would be 98·5 volts. But the moment we connect the idle feeders, the pressure in B and D rises to 101·5 volts, and current flows from B to a_2, from B to c_1, and from D to c_2, correspondingly diminishing the current in the feeders A and C. Lamps fixed up to a certain distance to the left of a_2, and to the right of c_1, will now be fed from the current in B, and the current from A and C will not reach so far as before. The point of lowest pressure on the main must evidently be that lying between the last lamp fed from A, and the next lamp which is already fed from B.

Let x be the distance in yards of the point of lowest pressure from A.

Let d be the distance in yards between A and B.

Let r be the resistance of the main out and home per yard run.

Let γ be the current taken from the main per yard run at full supply.

Let C_A be the current in A.

Let C_B be the current in B.

Then the following equations are self evident.

$$\frac{C_A}{2} = x\gamma \quad \frac{C_B}{2} = \left(\frac{d}{2} - x\right)\gamma.$$

The range of resistance on feeder B is determined by the ratio between C_A and C_B and to find this we must ascertain the distance, x, as given by the condition that the drop in pressure from A to M must be equal to that from B to M.

Since lamps are supplied all the way between A and M the loss, λ, is half that which would take place were the whole current flowing out from A to M and back from M to A. We have therefore

$$\lambda = \frac{1}{2}\,\frac{C_A}{2}\,x\,r.$$

Similarly the loss between a_2 and M is $\frac{1}{2}\,\frac{C_B}{2}\left(\frac{d}{2} - x\right)r$ to which must be added the loss between B and a_2 amounting to $\frac{C_B}{2}\cdot\frac{d}{2}r$. We have therefore

$$\lambda = \frac{C_B}{2}\left(\frac{d}{2} + \frac{1}{2}\left(\frac{d}{2} - x\right)\right)r.$$

By combining the two equations we have—

$$\frac{C_A}{C_B}x = \left(d + \frac{d}{2} - x\right).$$

But from the equations for the currents the ratio of C_A and C_B is $\frac{x}{\frac{d}{2} - x}$, hence

$$x^2 = \left(\frac{d}{2} - x\right)\left(d + \frac{d}{2} - x\right)$$

$$x = \frac{3}{8}d.$$

The point M lies, therefore, three times as far from A as it lies from a_2, and the feeder A must carry three times the current which the feeder B carries. The same ratio evidently applies to the other two feeders, the conditions being identical. We find thus that, even under these very unfavourable conditions of supply, the ratio between heavily and lightly loaded feeders is only 3 to 1, and the maximum resistance required in rheostat of, say, the second feeder is

$$\rho_2 = r_1\, 3 - r_2.$$

If the resistance of different feeders were approximately equal, then the greatest range which any of the rheostats need have to meet the case of unequal distribution above assumed is only about twice that of the resistance of each feeder.

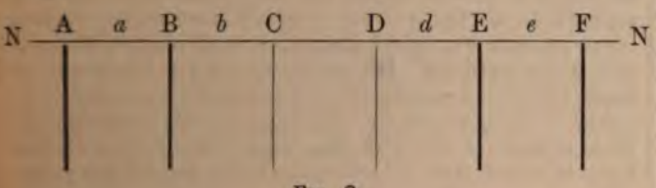


Fig. 2.

Now as to the other case of unequal distribution mentioned. If, as in Fig. 2, a pair of heavily loaded feeders is adjacent to a pair of lightly loaded ones, the current flows from B right and left towards *a* and *b*, but from C only to the left of *b*. Similarly the current from D flows only towards the right towards *d*, but not to the left, whilst the current from E flows right and left towards *e* and *d*. The point of lowest pressure must again lie $\frac{3}{8}$ of the distance between feeding centres to the right of B and to the left of E, but the current in the lightly loaded feeders will now only be half what it was previously, whilst that in the heavily loaded feeders has slightly increased. It is now 87·5 per cent. of the full demand instead of 75 per cent. as before. The ratio $\frac{C_1}{C_2}$ is thus increased to

$$3 \times 2 \times \frac{87{\cdot}5}{75} = 7.$$

With feeders of equal resistance, the greatest range of resistance of any rheostat would therefore be about six times the resistance of the feeder. A smaller range would suffice if we had assumed one of the lightly-loaded feeders disconnected altogether. It might be made a rule in arranging the regulating switches that any feeder should be disconnected as soon as the current it carries has decreased to—say 15 to 20 per cent. of the current in the heavily-loaded feeders next to it; and in this case the range of each rheostat need only be from three to four times the resistance of its own feeder. This is not an excessively large resistance, and there will generally be no difficulty in finding room for the coils without crowding them so as to impair their cooling capacity.

If the reader has followed us so far he will have seen that the problem of maintaining an almost constant pressure on town mains, even under greatly varying conditions of supply, is capable of an easy solution, and, as a matter of fact, has been solved in many American and Continental town installations in the manner we have here generally indicated. It is hardly necessary to point out that by the adoption of a multiple wire system the cost of mains can be slightly reduced, whilst the method of regulating the pressure at the feeding centres remains equally applicable. We have, however, left the more complicated systems of direct supply out of consideration, because the method of regulation is the same in all cases; and as we only dealt with elementary principles, we considered it preferable to show the application to the most simple case of a two-wire system working at 100 volts. There remains yet to be considered the question of economy. What percentage of the total electrical energy developed at the station is wasted in heating the rheostats? This question can evidently only be answered when the conditions of supply in any given case are definitely known. We select as an example the first case of unequal distribution described above, in which full supply and no supply alternate in the immediate neighbourhood of adjacent feeding centres. We found that under these conditions neighbouring feeders carry alternately $\frac{3}{4}$ and $\frac{1}{4}$ of their full working current. If the full supply is on all over the district, each feeder carries the full working current and loses 20 volts. At $\frac{3}{4}$ current the loss is therefore 15 volts, and at $\frac{1}{4}$ current the loss is 5 volts. We would therefore keep 116·5 volts at the main bars in the station, and short-circuit the rheostats of the feeders which carry $\frac{3}{4}$ of the full current. We would also adjust the rheostats of the other feeders (those which carry $\frac{1}{4}$ of the full current) so as to absorb 10 volts. If 1,000 amperes are being sent out, 750 amperes would thus go straight to the feeders, and 250 would go to the feeders through the rheostats generating heat equivalent to 2,500 watts. This energy is lost. The total energy developed is 116,500 watts, and that actually supplied to the feeders is $116{,}500 - 2{,}500 = 114{,}000$ watts. The efficiency of the regulating appliances is therefore $\frac{1{,}140}{1{,}165} = 97{\cdot}8$ per cent.

This is an exceedingly high efficiency, and only obtainable if we at all times regulate the dynamos as to produce exactly the pressure required by the heavily-loaded feeders, but no more. In practice, however, it is found advisable to keep at the main bars a slightly larger pressure, so as to have a small margin of regulation on all the feeders, but even allowing another 5 per cent. of loss on this account, the efficiency of resistances as regulators must still be greater than that of separate regulating dynomos, which we have already condemned on account of complication.

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

(*Continued from page 80.*)

12. *Electro-Mechanical Relations.*—Having defined the various units by which engineers estimate the work given to and obtained from dynamo machines, we have now to consider the relation which the mechanical and electrical sets of units respectively bear to each other. We have said that the work given to a machine is expressed in the form of a pressure into a distance, and the power in the form of a pressure into a velocity, while the work received from a machine is expressed by electric quantity into difference of potential, and power by current into difference of potential. The mechanical unit of work, the foot-pound, has its exact electrical equivalent in joules, while the mechanical unit rate of performing work, the horse-power, has its equivalent in watts. Much time and labour have been spent in determining these relations with accuracy, and the following figures give the results:—

Work	1 Foot-pound	=	1·356 Joules.
	1 Joule	=	·73725 Foot-pound.
Power	1 Horse-power	=	746 Watts.
	1 Watt	=	·0013405 Horse-power.

13. *Relation between Heat and Work.*—Of the relation between heat and mechanical work the reader has doubtless some knowledge. A railway train brought to rest at the platform by the application of the brakes is a familiar example of this relation. Here the visible motion of the train is rapidly converted into invisible molecular motion, the energy given up taking ultimately the form of heat. The kinetic energy of the train is transformed into heat energy when the brakes are put down, a resistance being overcome through a space, and work being thus performed as a result of the transformation. In the case of electric lighting it is evident that the energy of the current is converted into

heat in the arc and incandescence lamps; but it is also true that a certain amount of heat is generated when a current flows through the most perfect conductor. There is invariably some work done by the current in passing and the heat generated is an exact measure of this work. In the case of water flowing through pipes there is always due to the friction a certain amount of work done, and the heat generated due to this cause is analogous to the heat generated in conductors by the passage of a current. The rise of temperature in conductors is oftentimes very slight, because their resistance being low the work done in them is small. But when indifferent conductors, such as German silver or platinoid, are employed, the heating becomes very apparent for the simple reason that a greater amount of work is done per foot of length in sending the current through them. Between the work done and the heat generated in conductors there is a perfectly definite relation which has been carefully determinined. In England the unit of heat is the heat required to raise a pound of water from 0° C. to 1° C., and if the energy of the electric current is employed to generate heat we require for the production of each heat unit 1898 joules.

14. *Electrical Measurement.*—It is not the intention to describe here the various forms of instruments by which the work obtained from dynamos may be measured, but a brief reference, with a hint here and there relative to their use, may be made. It has already been stated that what it is desired to measure most frequently is the current flowing at any moment, and not the quantity of electricity which has passed after a given time. Instruments designed to measure the current are termed ampere-meters or *ammeters*, and are of endless variety, but the merits and demerits of the various designs need not be discussed here. For their action they depend on the property of the current to deflect a magnetised needle, or on the mutual action of two or more coils traversed by the current, or on the attraction between iron cores and current-carrying solenoids. In such instruments there may be a part which is caused to move in opposition to a controlling force, and which takes up a position depending upon the current flowing; or the controlling force may be adjusted by the observer until the force produced by the current and tending to move part of the system is balanced. In the former kind the parts on the mutual action of which the measurement depends have different relative positions for each value of the current, in the latter kind they maintain always the same relative positions. The former may be termed indicating instruments, because they continuously indicate the currents flowing without interference of the attendant. By means of a pointer attached to the moveable part of the instrument the current flowing from moment to moment is indicated on a dial graduated in amperes. Instruments in which a moveable part is balanced by the torque of a spring or by weights are termed zero instruments, because the moveable part is always at zero when a reading is taken, the force tending to move it from zero being balanced first. In these instruments the torque of the spring or weight in the scalepan measures the current flowing, but they labour under the great disadvantage of requiring manipulation by the observer before readings can be taken. For this reason their use is restricted, being employed only in the laboratory, where in some forms they are most useful as standards, or in practical work under circumstances which leave the user no choice. Zero instruments, although mostly out of place in the electrical factory or in installation work, possess advantages as standards for the reason that the force tending to disturb the balance can generally be expressed by some simple law, if the parts preserve always the same relative positions. If, for example, there are two coils lying with their planes parallel to each other, in both of which a current of the same magnitude flows in the same direction, the attraction between these coils is discovered to be proportional to the square of the current. Having carefully ascertained by balancing one coil against a scalepan the attractive force corresponding to any particular current, we can tell at once, knowing the law which governs the instrument, the force corresponding to any other current. Similarly we know that in the case of two coils having their planes at right angles to each other, the tendency for one coil to twist round until its plane corresponds with that of the other coil is also proportional to the square of the current, and to keep the coil at right angles a torque or twisting force proportional to the square of the current must be put upon it. The construction of Sir W. Thomson's balance instruments, in which the attractive force of current-carrying coils is balanced by weights, is based on the law stated, as is also the construction of the well-known Siemens dynamometer, both good instruments for use as standards. To calibrate such standards we have recourse to the deposition of silver, and great care must be taken in making the determinations. The silver bath is placed in series with the instrument, and the current, which must be maintained constant, derived from a secondary battery. After a certain time the deposited metal is carefully weighed, the current flowing during the experiment having been

$$\frac{W}{\cdot 017253t} \text{ amperes,}$$

where W is the weight of silver deposited in grains, and t the time in seconds during which the experiment lasted. The result should be checked with currents of different magnitudes, and once having obtained the balancing forces corresponding to various currents, the instrument, being one not liable to alteration, and with a known law, can be employed for calibrating all kinds of ammeters for practical use.

For the measurement of differences of potential, *voltmeters* are employed which depend for their action on some of the properties of the current already mentioned, and the remarks made regarding ammeters, with respect to instruments employed for practical work and for laboratory use, apply equally to voltmeters. A voltmeter is really an ammeter of high resistance. It has its coils wound with a large number of turns of fine wire, instead of with a few turns of coarse wire, its resistance being often some millions of times greater than that of an ammeter. The current passing through it is consequently very small, its magnitude indicating the volts at the terminals. The terminals are connected by wires to the two points between which it is desired to measure the difference of potential, and the dial of the instrument is generally graduated in volts that the difference may be directly read off. In using voltmeters one must be careful to let the current flow through them only while a reading is being taken, in order that errors due to heating may be avoided. The current flowing through the instrument to indicate the volts depends only on its resistance, and if from heating the coils by the passage of the current the resistance increases, the readings obtained will obviously be lower than they should be. It is preferable to select for use as a standard a zero instrument, which, moreover, must not be liable to alteration with time. The standard may be calibrated by comparison with a cell of known E.M.F. in the following way. If we have a current flowing through a number of resistances we know from Ohm's law that the total difference of potential is to the total resistance as the difference of potential between any two points is to the resistance included between them. Suppose now we have a number of resistance coils, the values of which are known, connected in series with an unknown difference of potential, V, which may be produced by a secondary battery at the terminals of the set. To these terminals the standard voltmeter which is to be calibrated is connected, and our object is to find the value of V producing an indication on that instrument. Call R the total resistance of the coils. Connect the standard cell in series with a sensitive galvanometer and key, and let the two wires leading from these be connected up to embrace a part, r, of the resistance R. Knowing the direction of the current in R, let the cell be arranged so as to oppose any current which, due to the difference of potential between the ends of the wires, would be sent through the cell and galvanometer. Depress the key, and adjust r, until no current flows. Then the difference of potential between the two wires is equal to the E.M.F. of the cell, and

$$V = \frac{E\,R}{r},$$

where E is the E.M.F. of the cell in volts. Care must be taken to make momentary contact only with the key, as a current through the cell when r is some way from adjustment is liable to polarise it, thus altering its E.M.F.

By taking several observations in this way the values of the indications throughout the whole scale of the instrument can be taken, but the resistance of the coils should be very high and the current very small in order to prevent errors arising from the heating of the coils.

(To be continued.)

EFFICIENCY TESTS OF ELECTRIC MOTORS FOR AMATEURS.*

BY W. F. D. CRANE.

My purpose in presenting this paper before the association is to describe clearly and briefly, for the benefit of those who as yet have but a limited knowledge of electricity, the methods and apparatus employed in the tests for determining the efficiency of an electric motor.

As is well known, any self-exciting dynamo can be used as an electric motor by reversing its function as a generator and supplying it with electrical energy to be converted into mechanical energy. Hence, it will be seen that the methods and apparatus described below are equally applicable for determining the efficiencies of dynamos as well as motors, with this distinction, however, that since the efficiency of any machine is the ratio of the power put into the machine and the useful work given out, in the case of a dynamo, we have to determine the ratio of the mechanical work expended in turning the armature to the electric energy produced. In a motor we wish to find just the reverse—that is, the ratio of the electric energy contained in the current supplied to the motor to the mechanical energy given out in useful work.

The losses occuring in both machines during the conversion of electrical into mechanical energy, and *vice versa*, are identical, and may be localised as follows:—

1. Friction at the bearings; air friction, due to the rapid revolution of armature; and the friction of the brushes against the commutator.

2. Energy lost in the heating of the wires in armature and field coils; voltaic leakage, or leakage between the wires, and a certain loss due to self induction.

3. Magnetic leakage into the air and loss by the production of eddy or Foucault currents in the iron parts of the motor. These eddy or Foucault currents are useless currents which are set up in the iron in armature and field magnets by the mutual inductive effects of the magnetism in armature and field magnets and of the current passing in the armature.

The energy of a current can be expressed, provided we know the number of amperes and the number of volts of potential between the two ends of that part of the circuit in which the energy to be measured is being expended. The number of amperes is measured by a suitable amperemeter; the number of volts by a suitable voltmeter. The product of the volts into the amperes expresses the electric energy expended per second in terms of the unit of activity, denominated "watts." As one horse-power is equal to 746 watts, the number of volt-amperes (*i.e.* watts) must be divided by 746 to express the result in horse-power. But the current equals the E.M.F. divided by the resistance—Ohm's fundamental law—or, $E = CR$, and $CE = C^2R$. Hence it will be seen that, if we can determine any two of the three quantities E, C, and R, belonging to the armature, shunt, or main coil circuits, we can find the electrical horse-power in that circuit.

For example, suppose we want to find the electrical horse-power consumed in the armature of a motor or dynamo. We find its resistance R, when the machine is at rest, measure the current C passing through it when the machine is in motion, and by the above formula, C^2R, readily determine the number of watts consumed therein. Dividing by 746 gives us the horse-power.

There are three efficiences which we may test for in an electric motor, viz., the efficiency of conversion, the electrical efficiency and the commercial efficiency.

The efficiency of conversion is the ratio of the electrical energy supplied at the terminals to the power actually obtainable at the armature shaft; and this should never be less than 90 per cent. in medium sized and large motors. The balance, or 10 per cent., would be the percentage of energy wasted in the losses enumerated in (2) and (3), and would include the percentage of loss due to defective construction and an ill-proportioning of parts composing the motor. Or, expressed in symbols,

$$E_c = \frac{w + f}{E\,C}; \quad \ldots\ldots \quad (1)$$

where w is the useful power given out, f the friction, both being expressed in watts, and E C the electric energy supplied, as measured at the terminals.

This formula shows the capacity of the motor for utilising the energy of the current supplied, and its determination is useful in that it shows the proportion of the electrical defects, and also requires a determination of the loss from friction, which may lead to its economic reduction.

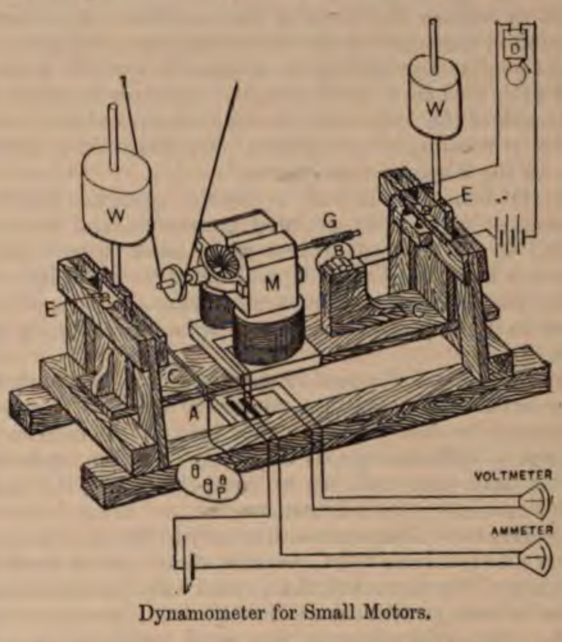
The *electrical efficiency* is the ratio of the external electrical energy to the total internal electrical energy; that is, to the total electrical energy consumed in armature, shunt or main coil circuit.

Or, $$E_e = \frac{K}{EC}. \quad \ldots\ldots \quad (2)$$

The *commercial efficiency* is the ratio of the external electrical energy applied to the useful work given off.

Or, $$E = \frac{w}{EC}. \quad \ldots\ldots \quad (3)$$

In measuring the mechanical power given off by a motor, or consumed by a dynamo, it is now almost



Dynamometer for Small Motors.

universal to employ the Brackett cradle. This, as shown in the accompanying diagram, consists of a firm bed and uprights, the tops of which support the cradle proper C resting on knife-edges E. The motor is accurately centred on this cradle, so that the axis of the armature passes through the points of support of the knife-edges. Counterbalancing weights W W are so placed as to balance the weight of the motor M, scale pan P and dynamometer arm A projecting horizontally from knife-edges. A friction brake or suitable apparatus, connected by belt with the motor pulley, is placed vertically above or below for the purpose of consuming the power given off by the motor for various currents and at various speeds. In lieu of a suitable brake a dynamo may be used, with adjustable lamp or resistance loads. The revolutions are counted by means of a wheel and worm G inserted at the end of the armature spindle. A platinum point at B on the side of the wheel comes in contact with a spring or mercury cup at each revolution, thereby ringing a single stroke electric bell D. All external connections in testing small motors should be made in mercury, so as not to introduce errors which would otherwise arise if wires were led directly to the motor.

* Paper read before the Electrical Engineering Association of Cornell University, December 9, 1887.

The figure shows a wooden cradle designed for the testing of small motors not much over $\frac{1}{8}$ h.-p. This cradle is built of well seasoned ash with a base 28in. long, is one-third as wide, and the supports are about 1 foot high. The supports are placed $19\frac{1}{2}$ inches apart, and carry on their tops grooved steel plates as bearing surfaces for the knife edges. The swinging cradle has an available platform 16 inches long by 6 inches wide. The knife edges are rigidly attached to nuts threaded upon the vertical iron bars supporting the counterbalancing weights. This permits of a limited adjustment of the cradle proper vertically in either direction, which adjustment, when made, is rendered secure by a lock-nut on the top of the cradle where the rod protrudes from the wood. When testing for such small powers it is especially necessary, for the sake of accuracy, that all extraneous friction or displacements should be avoided; hence all connections are made in floating mercury, as shown. The dynamometer arm is 30 centimetres long, and a short scale (not shown), projecting from the side of the support, serves to show when the cradle has reached its position of equilibrium, or zero point. In large cradles, designed for testing machines of several horse-power, the scale pan is replaced by a weight sliding on the dynamometer arm and the speed is taken by hand with an ordinary dial speed counter.

By this cradle arrangement the motor is virtually converted into its own dynamometer. The instant that it does work there is a reaction between the armature and field magnets which causes a displacement of the cradle. By placing weights in the pan, the dynamometer arm can be restored to its position when at rest; then the couple formed by the weight in the pan and dynamometer arm serves to balance the force of the reactions. By a determination of the speed at the same time, the power given off in foot-pounds per minute is expressed by the formula $w = 2\pi Pdn$; where P is the weight in the pan in pounds; d the length of the dynamometer arm in feet, and and n the number of revolutions per minute. Dividing this by 33,000 gives us the horse-power.

Or this formula, when P is given in grammes and d in centimetres, gives w in gramme-centimetres, and must be divided by $7{\cdot}6 \times 10^6$ to express w in horse-power; or, to express it in watts, it must be multiplied by 981×10^7.

The current and potential measuring instruments are placed in the circuit as shown diagrammatically in the figure.

The friction may be readily determined by revolving the motor armature by another motor or suitable apparatus substituted in the place of the brake. Dynamometer readings at different speeds may then be taken, as before. The terminals must be open to avoid converting the motor by this reversion into a dynamo.

We have now all the terms necessary to find the efficiency of any electric motor. In practice, simultaneous readings are taken of the current E.M.F., speed and dynamometer.

The following table shows the tabulated results of tests for the commercial efficiency of a small series motor, such as is used for running sewing-machines and other light machinery. The column under "Dyn." gives P in grammes:—

C.	E.	E. C.	Speed.	Dyn.	W.	Eff.	H. P.
10	8·75	85·5	1,440	154·5	41·14	·47	·055
10·5	10·45	109·7	1,920	150·	53·25	·485	·071
10·5	12·07	126·73	2,400	140·	63·13	·49	·084
10·07	13·87	139·74	3,240	126·	75·49	·54	09

To find the efficiency of conversion, we may take as an example the data of the first test, when the motor was running at a speed of 1,440 revolutions per minute, with a current of 10 amperes, and giving an output of 41·44 watts. The friction at the same speed was 8·3 watts. Substituting in (1) we have

$$\frac{w+f}{EC} = \frac{41{\cdot}14 + 8{\cdot}3}{87{\cdot}5} = 57 \text{ per cent., nearly.}$$

The resistance of the armature was ·2 ohm, and of that of field ·28 ohm, a total of ·48 ohm. Taking the same test when the current was 10 amperes, the total internal electrical energy consumed in armature and field coils would be $C^2 R = 10^2 \times {\cdot}48 = 48$ watts. We then have for the electrical efficiency, by substituting in (2),

$$\frac{K}{EC} = \frac{48}{87{\cdot}5} = 55 \text{ per cent., nearly.}$$

Though the cradle above described is built on a plan of lightness and of a size for the accommodation of motors of less than one-quarter horse-power, it will serve as an illustration of the cradle enlarged and constructed wholly of metal for the testing of motors of many horse-power. There are many dynamometer methods, and several modifications of the Prony brake, which have been used with more or less accuracy for determining the power given off by a motor; but the Brackett cradle has the great advantage of permitting of very delicate adjustment, and ease and accuracy of dynamometer readings. Its *disadvantage* consists in the time and excessive care necessary in the mounting of the motor and making of all adjustments, which make it an instrument more suitable for the laboratory than the practical requirements of the workshop.—*Electrical World.*

JUVENILE LECTURES.

The second of this course of lectures on "The Application of Electricity to Lighting and Working" was delivered at the Society of Arts on January 11th, 1888, by Mr. W. H. Preece, F.R.S., from which we abstract the following:—

Last Wednesday I had the pleasure of showing you how electricity was employed to produce heat, and how, by means of the heat resulting from the passage of electric currents, we obtained light. To-night I intend taking you in a different direction altogether. I want to disabuse your minds of the idea that electricity is a prime mover in the sense we generally consider prime movers to be. It is nothing of the sort; it is simply an agent or a medium by which energy, such as I showed and described to you last Wednesday, can be passed through one of its stages. The first form of energy that I am going to call your attention to to-night is of the character generally called work. It means something done; objects moved, resistance overcome.

In all these actions of electricity that I am going to show you—if an electric current, for instance, moves a magnet, a magnet moved will produce electricity; if an electric current, as I showed you last Wednesday, produces heat, heat in its turn will produce electricity, and so we have throughout the whole range of mechanics and of science this principle of reversibility introduced. For another instance: suppose we compress air or gas, the gas always reverses the action, and exercises a reaction precisely equal in amount to the action that caused the compression. Take a letter-weight. If you want to weigh a letter you do so simply by compressing a spring, and the weight of the letter is measured by the reverse action of the spring in pressing the letter upwards. If you take a weight and lift it, wherever it may be, that weight is in a position to produce the reverse action. If we take two magnets or two currents of electricity and forcibly separate them, there is also always this reaction between them.

I want, in the first place, to show you what is meant by a magnetic field. We have now on the screen the projection of a steel magnet, it has been charged with magnetism, and as Mr. Carpenter now scatters over a glass placed above that magnet some very fine iron filings, you see that they arrange themselves in straight lines and curves, and when the glass is gently tapped those lines all arrange themselves in a radial fashion, with beautiful symmetry, in the most wonderful way, every particle being directed by attraction towards the pole; one pole of the magnet only can now be seen, though, of course, every magnet has two poles. From that I want you to see how those lines picture to us the conditions of the space that surrounds every magnet, and in every single experiment that I am going to show you to-night the currents that we obtain are currents due to the fact that we can force copper conductors to pass through what is called a magnetic field; the neighbourhood of a magnet, such as you saw just now on the screen, is called a magnetic field. Whenever a

copper conductor, such as the wire I now have in my hand, or a wire arranged in other forms, is caused to pass through a magnetic field, it becomes electrified—it acquires that condition which enables us to obtain currents, and to use those currents.

I will now show you that we can utilise currents produced by this hand dynamo to attract and repel particles of iron. You now see on the screen two poles of an electro magnet; the difference between a permanent magnet and an electro magnet is that the one is made of steel and the other of soft iron. The permanent steel magnet acquires and retains in magnetism for a long time, whereas in an electromagnet the magnetism only exists during the time that a current is passing round the soft iron core. The picture shows the two coils of copper wire which, with their cores, form the electromagnet. Mr. Carpenter places some iron filings on that magnet, and on raising it they simply fall off, because there is no power present to attract them; I now cause a current to pass, and the iron filings being presented they are attracted, and continue so as long as the current is passing. The moment the current ceases the filings fall. That experient failed at first, because a loose connection of one of the wires had been made, and no current passed. Faraday once made a remark that an experiment never failed. He said, "An experiment never fails; something happens that requires further investigation!" In that experiment we have seen one of the simplest and most interesting elementary experiments in electricity. You have now seen that in a magnetic field we have the production of certain lines of magnetic force, and that currents of electricity produce magnetic fields. I want now to show you that whenever a conductor is passed through a magnetic field, work is done upon that conductor, it receives a kind of reaction, currents of electricity are produced. Similarly, if the conductor be placed in the magnetic field and a current from another source be passed through it, it is urged to move in a certain direction.

The fact that I want you to understand is, that whenever we pass a current of electricity through a conductor in the neighbourhood of a magnet, or in a magnetic field, it has a tendency to be moved or to rotate around that field in a definite direction. Here I have a horseshoe magnet; it is surrounded by a cage of copper wire, and through that cage I will cause a current of electricity to flow. You now see that the coils are rattling round at a rapid rate. I take the current off, and they stop; I put the current on again, and away they go. There you have an illustration of the fact that whenever you have a conductor in a magnetic field, and the conductor is traversed by a current of electricity, it is always urged to move.

I ought to point out to you that here we have the basis of every single experiment I am going to show you tonight. A current of electricity produced rotation, as you saw, in that cage, and in this particular form that I want to show you on the screen you will see that rotation is produced in another way. You now see the apparatus on the screen. On the left and right hand side there are two upright columns, the poles of the magnet, exactly similar to the one I showed you on the table. Between those two poles there is an iron armature rotating on a centre point, and that armature is enveloped at each end by a small coil of copper wire. When a current of electricity passes through that copper wire it magnetises the iron bar, and the iron bar gets attracted and repelled by the two poles of the magnet, so that on my now putting the current on, you see, away it goes. The application of that principle has been carried out in the little apparatus I have here, called Froment's motor. This particular Froment's motor is used to wind a clock; in fact, it has only just been taken from a clock which, at twenty minutes past every hour, was wound up by a current of electricity actuating this motor. By its means the hand winding of clocks is dispensed with, and, supposing a battery will last for years, so the clock will keep time for years without one being troubled by the necessity of going round the house and winding up the clocks.

I will now show you how electric currents can be used to produce rotation or to produce motion. The history of motors is extremely interesting; it commences in the year 1823, when Mr. Barlow, the father of the present well-known engineer, the engineer of the Tay Bridge, and past President of the Institution of Civil Engineers, showed how it was possible to produce rotation by means of currents of electricity. The great apostle of electricity, Faraday, in 1831, did the same thing; and in 1833 Ritchie produced that very instrument that I showed you; but as far back as 1839 there was a Scotch gentleman of the name of Davidson, who thought that this principle was applicable to the drawing of trains on railways, and I have a slide, which Mr. Carpenter will now throw upon the screen, showing his locomotive.

You now see a picture of that machine, as used on the Edinburgh and Glasgow Railway, or rather, I will not say it was used, because I do not think it could have been used, but it was tried on that railway as far back as 1842. You see there were eight electro magnets, through which currents were passed, and these rotated the wheels. The machine worked at the rate of 9 miles an hour. Other distinguished scientists have worked in this direction. Jacobi, of St. Petersburg, about the same time, drove a boat on the River Neva by means of an apparatus very similar to Davidson's. Froment, whose apparatus I showed you, applied this principle to his workshops in Paris; the tools in his shop were worked by an exactly similar motor to that which I showed you just now. Motors are innumerable; I have on the table here models of various patterns. Mr. Immisch has distinguished himself very much in this direction, as has Mr. Parker and others. I want to illustrate to you the property that the electric current has of transferring power from one place to another. We can produce power in this room, and we could, without difficulty, transfer the power produced here to Liverpool, to Edinburgh, or even to New York; there is absolutely no difficulty whatever in transferring from this very room energy produced by means of the dynamo machine, and sending it, if you like, to Kamtchatka. Of course, the amount of energy you are able to transmit is quite another question; the amount varies very much with distance. Telegraphy is entirely dependent on the power which electricity gives us to reproduce mechanical effects at a distance. By this power we are able, in telegraphy, to transmit signals to any distance we like. This power is used for winding clocks, and for a great many practical purposes.

There is a friend of mine near East Grinstead, Sir Francis Truscott, who has his house fitted with electricity. He used to employ two men every day in raising water from a depth of 150ft. to fill his tanks, but when he had secured the use of electricity for lighting his house, I suggested to him that he might just as well use it for raising his water. It was no sooner suggested than acted upon. A little motor, not much larger than that you just saw, works for two hours a day, and supplies a full quantity of water for the house, and the services of the two men were dispensed with in that respect. There is no reason on earth why those people in the country who depend upon manual labour for the raising of water cannot raise their water with greater speed and more efficiency by means of an electro motor; in fact, this is carried out to a very large extent in South Wales by Mr. Brain. In the collieries in the Forest of Dean electro motors are used to a very large extent to raise water from depths of hundreds of yards, and through distances that approach from a mile to two miles. Well, the same power exactly that can be used to raise water can be used for many other purposes.

The present Prime Minister of England is a very advanced electrician. There is no man in England who has applied electricity so much for domestic and useful purposes as Lord Salisbury has at Hatfield. He was one of the earliest in the field; he has at Hatfield currents of electricity which are not only used for pumping but also for chaff cutting, turnip cutting, for sawing timber, and for many other farming and domestic purposes.

To-night I am also able to show you this operation of sawing by electricity. Sawing in country houses like Lord Salisbury's is required for cutting up the timber used for fires and for many other purposes, and here we have, by means of this motor, the counter-shaft and the circular saw at work.

(To be continued.)

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NOTICE.

With our issue of January 6 we gave a Portrait of E. Graves, Esq., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. Wollaston, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* Sir Humphrey Davy, F.R.S., *whose fame as an electrician is still more prominent than that of* Wollaston. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* Prof. D. E. Hughes, F.R.S.

THE CITY FATHERS.

Does any one read Ruskin now-a-days, or anything besides the daily paper? In lecture VII., "Ethics of the Dust," the lecturer, asked by the children to tell them about virtue, bluntly says: "I'm tired, and cross, and I won't," but for all that the delightful dialogue goes on to the students' edification if not to the children's. Surely the "City Fathers," in the shape of the Commissioners of Sewers, must be tired, or cross, or won't, say the final words that will enable one more firm step in advance to be taken with regard to electric lighting. According to the latest advices, however, the dialogue will be concluded next Tuesday, and then we shall know the result of several years' negotiations. Meanwhile, as the Chaldee manuscript has it, chap. iv., v. 14, "the man which is crafty began to take courage when his friends were gathered unto him, and he took his trumpet with boldness, and began to blow for them over which he had power." Which dark saying might be variously interpreted, as one has it, "the reference is to a cutish man who in other days flourished for a season, while for a season he followed the plan of 'Brer rabbit' and 'lay low,' till by-and-bye the opportunity came to trade upon the confiding public over whom the power of many words prevailed to their ultimate annoyance and loss."

It is useless to hide our meaning under the verbiage of old books, principally because so few have time to study ancient literature or to understand the allusions made therein. Delay on the part of the "City Fathers" is leading to difficulties. We will not argue that London should have the electric light; that would be useless—it is admitted. It is well known that the Brush Company have for a long time been negotiating with a view to carry out the work, and it is as well known that the contracting parties are virtually agreed. All that remains is to say the final "yea." The lingering over this "yea" has permitted two more Richmonds to enter the field. The Brush Company, as we say, has practically agreed with the Corporation, to light certain districts, with certain powers granted to them and conditions attached thereto. These powers and conditions are principally interesting to the contracting parties, and not to outsiders. The South Metropolitan Electric Supply Association is promoting a provisional order which, if granted, gives the Company certain powers over a portion of the area already, so to speak, filled by the Brush Company. Further, there jumps up a third company, who will seemingly go anywhere and do anything provided some fifty householders will take two thousand lamps. Unless there is a good deal more self denial exhibited than is usually the case in company working, we foresee some bitter antagonism, even if not costly litigation. Three rival companies working in one street will neither do good to themselves nor to the industry

they represent. The misfortune in this particular case is that one company is thought to favour an underground system of distribution, another an overhead system, and the third whatever chance may throw in its way, so that the sole right possessed by one to take up the streets would not interfere with the wayleaves of the others. If any suggestion would find favour in the eyes of conflicting interests, it would be well if the South Metropolitan would consider the advisability of restricting the area desired, to something altogether outside that under consideration by the Brush Company, and that the House-to-House Company again should confine its efforts to districts outside either the South Metropolitan or the Brush. It may be said that our views are in favour of monopoly; so they a in "are question of breeks and sich like"—in other words our views are that success in central station lighting necessitates a kind of monopoly. One company, having selected its district, should be free from the competition of any other company, unless obviously unable to carry out the proposed work, then its position would simply be that of the dog in the manger, and the sooner a strong hand turned it out the better. The Brush Company was first in the field, it is able and willing to do the work, and only waiting the sanction of the Corporation. It may be the South Metropolitan is just as able and willing, but in the overlapping area they were not the first in the field, and should therefore retire. The competition of the House-to-House Company cannot be taken seriously. Companies desirous of doing work do not make their desires known through the advertisement columns of financial papers; but on the other hand such a method of procedure is just what one would expect of a company whose principal basis of work savoured somewhat of the speculative kind. London prides itself upon being the first city in the world, but in many ways it should be classified lower down, and especially is this the case in accepting improvements. Berlin, Vienna, New York, Paris, Brussels, have all more consistently adopted the new light than London, yet the benefit, if the light were adopted in the latter, would be incalculable. We do not advocate the light as a luxury; we contend it is almost a necessity. The work carried on in our busiest thoroughfares would be carried out more expeditiously, and at much less cost and inconvenience if there were more light. Neither the initial cost, nor the cost of maintenance are the sole questions to be considered in obtaining more light, and we trust next Tuesday will bring the final settlement of the matter, so that the work may at once be proceeded with, and London the sooner put upon a better footing so far as the lighting of its streets is concerned. There is plenty of room in the modern Babylon for several companies to work harmoniously, and every effort should be made not to rush into disastrous competition to obtain a footing in any particular district.

THE PARIS EXHIBITION OF 1889.

Although we are unable to give a detailed report of the proceedings at the preliminary meeting of possible exhibitors held at the rooms of the Society of Telegraph Engineers on Monday last—as that meeting was scarcely of a public character—we may be permitted to refer broadly to the work being carried out.

The experience gained by the Society during the Exhibition of 1881, if for no other reason, makes it the best medium for organising that of 1889, and it may now be taken for granted that the Society will undertake the onerous and heavy duties involved in such organisation. A considerable number of the best-known firms engaged in the industry have been approached by Mr. Aylmer, and many have definitely stated their intention to exhibit. The days are young yet, and though Mr. Aylmer is possessed of a large amount of energy, many firms must necessarily be left to be dealt with by circular. Probably one of the first acts of the Society will be to issue a circular to all engaged in the industry. It has, we believe, been suggested that the society should act in 1889 as it did in 1881 in the matter of common expenditure by the exhibitors, that is, the expenditure for decoration, cleaning, for laying pathways, receiving and expediting parcels, etc. A guarantee fund was subscribed in 1881, but so great was the economy of a single instead of a multitude of paymasters, that the larger part of the fund was not required. The best way to provide for such common expenditure is for each exhibitor to contribute a *pro rata* sum according to the number of square metres he requires. It must not be forgotten by exhibitors in applying for space that if their exhibits will cover say x square metres they really require from 50 to 100 per cent. more space for pathways around these exhibits. A rough estimate of such expenditure would give 30s. per square metre as a minimum and 60s. as a maximum. This is altogether outside of personal payments, though as a matter of fact it decreases the personal expenditure by a larger amount than is paid into the collective fund—in that it is more cheaply to do the work collectively than individually.

TAUNTON.

One of the healthiest signs in the history of electric lighting is found in the first annual report of the Taunton Company. This Company, it is true, has had many advantages. It has not been heavily handicapped by promoters; nor has it paid fabulous sums for patents. It is really a local company, formed by local men, with local money to do local

work. This is as it should be, and if more companies are founded upon these lines, the greater will be the success of electric lighting. Of course the installation is but a little affair after all, yet it shows conclusively what can be done when working on a firm foundation. Two or three things have contributed to the success at Taunton. In the first place Mr. Massingham believed in the light and in himself. As a private individual, in a private adventure, he had to make it pay, and when the work grew beyond his control, he was satisfied with a moderate return. In the next place the arc-system adopted is one of the best, and it is exploited by one of the most conscientious firms at present doing business in England, whose work, so far as we know it, has been found to be thoroughly trustworthy. Lastly, the Company seems to have obtained an earnest, hardworking and capable electrician. Just as at Brighton, success has been due more to the personal efforts of Mr. Wright; so at Taunton, Mr. Massingham's labours have been admirably seconded by his electrician. Numbers of towns are hankering after the electric light, and we trust many will follow the example set them by Taunton. Make the work of local interest, carry it out with local capital, and the most pessimistic prophet will be compelled to say "All will be well."

THE TARIFF WAR.

(*Communicated.*)

The report of the proceedings at the meeting of the Anglo-American Telegraph Company has just been published. It is very amusing to see that what the shareholders call a "fighting rate," and what has been universally regarded as such, should be now spoken of by their Board of Directors as a "trial" rate, after doing their best to strangle the Commercial Cable Company—when in the interests of the cabling public that company lowered the tariff for messages between the two Continents. The pool as good as acknowledge their inability to accomplish their purpose by entirely changing front, insisting that the present 6d. rate is maintained as a "trial," when in reality it was introduced, upon their own showing, for quite another purpose, viz., when they stated, in so many words, that if the Commercial Company would not agree to charge 60 cents a word they would wipe them out by reducing the rate to 12 cents a word. This was, indeed, endorsed by Mr. Pender at the Direct Company's meeting in January, 1887, when he is reported to have said that "the only way to ruin the Commercial Cable Company is to adopt a low rate." This is a trial rate indeed, but only too evidently not introduced for the object of testing its practicability, but solely for extinguishing the Mackay-Bennett combination.

It is worthy of remark also that the only sensible utterance at the Anglo meeting was made by one of its own shareholders. "Why, it is contemptible," said that gentleman, "at this age of commercial civilisation, to talk about a monopoly in any business. The bottom of the Atlantic is no man's property, and it is open to all. It is infatuation to demand such a result. His lordship declared in this room that the 6d. rate was *not* to 'crush competition.' Mr. Newton says you must crush opposition. Crush Mr. Mackay! Yes. I should like to see you do it!" (Laughter.) Evidently no satisfactory reply could be made to this suggestive statement, as none was forthcoming. The great increase in traffic, of which the Board boasted, took place during the time the Commercial Cable Company adopted the shilling rate. It was as impracticable as it was absurd to pretend to base a policy when the conditions were so unfavourable; for further increase could hardly be maintained when the Commercial, for reasons to be stated, adopted the pool's 6d. rate. The result was inevitable, and should have been evident to the meanest comprehension, but the pool made a huge mistake when they thought that the 12 per cent. rate would have the effect of isolating and crushing the Commercial Company. It was thought that the single independent company would stand no chance against the united strength of the monopoly, but the facts of the situation have been intelligently grasped by merchants and others, and instead of succumbing to the enemy and crying for mercy, it seems by overtures made to Mr. Mackay that the enemy would be only too willing to come to terms of a very different character to those at first demanded.

The action of the Commercial Cable Company compares favourably with that of their opponents. That Company was established by honest and wealthy men, who, disdaining the watering of its stock, and not afraid of spending money, were nevertheless undesirous of ruining or attempting to ruin the pool. There was room for an independent company, and Mr. Mackay and Mr. Bennett threw themselves into the breach with the intention of getting a share of the traffic by means of a fair and just competition. The public who hate monopoly heartily co-operated and supported very fully that free and independent service. If the Commercial had been originated by schemers, started with a view of crushing the pool, or with the desire of being bought off at an advance price, the promoters surely would have started business at 6d., instead of which they simply reduced the then existing rate of 2s. by a trifling 4d. The public expected this reduction just as they expect the adoption of a permanent 1s. rate in the near future. Indeed, the Commercial Company was founded upon the express understanding that all profits over a certain margin, which would permit of a 5 per cent. or 6 per cent. profit on the capital outlay, should be devoted to the further reduction of the tariff. At the 1s. 8d. rate the receipts of the pool averaged £2,000 a day, whereas now they were making only £800 during the same time. After a fifteen months' trial of the 1s. 8d. rate, they announced that that rate was not, to them, sufficiently remunerative on their £12,000,000 of watered capital, and consequently they proposed to the Commercial Company a 60 cent per word rate, or else a threatened utter destruction at 12 cents. The first proposal was emphatically refused, and the pool began the fight by reducing the rate to 6d. Well, now the Commercial might have been expected to follow suit, but as they wished to prove to the public that not only were they not responsible for the fight, but were also opposed to a rate which scarcely paid expenses, and which was therefore prejudicial alike to the best interests of the promotors and shareholders, they met the 6d. drop by reducing their rate for the time being to 1s., and promised that as long as they were supported they would never exceed the 1s. 8d. rate. The 1s. rate was maintained by the Commercial Company for 16 months, when their customers expressed their friendly opinion that the difference in the two rates was so great, and that the fight had been so unequal and protracted, that they felt it was high time to adopt the 6d. rate also. This request was acceded to by the Company, but it cannot be too often reiterated that the advocates of the higher tariff, which was resisted by the Commercial, were the very first to introduce the 6d. rate, and, that being so, they will have to bear the consequences and pay for it.

One of the shareholders at the Anglo meeting found a solution to the question—"The longest purse will bring the others to terms!" This is in a nutshell what the Board calls a "trial" of the 6d. rate.

The telegraphing public that have used the Commercial Company's cables speak exceedingly well of the service, and from what we hear it is doubtful if the pooling companies will so easily arrange rates as is expected. If the Commercial Company do not hurry the raising of the rates, it will be a poor look-out for shareholders in the other companies, and it will be interesting to notice how much longer they will be prepared to support directors in a policy which, so far, has led to nothing but disaster.

CORRESPONDENCE.

EARLY TELEGRAPHY.

To the Editor of The Electrical Engineer.

Sir: In a note at page 122 you ask who can give any information about the telegraph scheme of the South Eastern Railway Company constructed in 1847? This was a double needle system erected by Cooke, the late C. V. Walker being his assistant and remaining in charge until his death in 1882. Walker wrote a charming little book called *Electric Telegraph Manipulation*, which was published in 1850, and is well worth reading.—Yours, &c.,

W. H. Preece.

WATTS-HEURES OR WATTS-HEURE.

To the Editor of the Electrical Engineer.

Sir: According to the rules for forming the plural of compound words, the first is the right form, for we have basses-tailles, plains-chants, chéfs-lieux, choux-fleurs, &c., but then there are exceptions, such as chevau-légers, grand'meres, appuis-main, bec-figues, and so on. The exceptions seem to be almost as numerous as the cases in which the rule is followed. *Moral*: Please yourself.—Yours, &c.,

R. B. P.

THE INSTITUTE OF ELECTRICAL ENGINEERS.

To the Editor of the Electrical Engineer.

Sir: As reform is the order of the day, may I venture to propose some slight alterations in the procedure of the Institute that, I venture to think, would add considerably to the value of its discussions.

In the first place, I would ask if it is not possible to arrange that proof copies of papers to be read shall be in the hands of members a few days at least before the meeting at which they are to be discussed? I take it that the discussion of papers forms quite as valuable a part of the Institute as the reading of them; in fact, in many cases the discussion is of far greater importance than the paper itself.

I take it, too, that it is practically impossible, except in special cases, for men to give their best thoughts in their best form in a discussion immediately following the reading of a paper they only then make acquaintance with. Everyone who has attended the reading of a paper knows that it is often exceedingly difficult to follow the paper through, much less to discuss it immediately after. The author's wording, though clear to himself, often requires some thought on the part of a reader before he thoroughly grasps the author's ideas; and if this is so, how can it be possible rightly to understand what he hears read for the first time, and not by the author. Other institutes arrange, in some form or other, that members can, if they choose, have copies of the paper beforehand; and I venture to think that the result of that wise provision is to very greatly enhance the value of their discussions. If anyone doubts the point I have raised, let him compare the discussions when papers have been adjourned to the next meeting, proofs meanwhile being in the hands of members, with those taken on the same evening immediately following the reading.

I am aware that the Council have in many cases experienced considerable difficulty in arranging for discussions of papers, not on the same evening that they have been read, on account of the time at their disposal; and I therefore welcome the suggestion that was thrown out in your columns of an increased number of meetings. Why not meet every week if there are sufficient papers to fill up the time and allow every paper to be thoroughly discussed. Another point on which I venture to offer a suggestion is the length of time alloted to individual speakers. I take it again that in a discussion we want as many minds as possible to give us their ideas upon the subject in hand, and that the Institute is hardly fulfilling its functions if the same members monopolise the whole of the available time at each meeting.

As the whole time of the meeting only amounts to two hours, out of which at least from fifteen to thirty minutes is unavoidably taken up with routine work, &c., it follows that, if one member speaks for an hour, the time left for others is very small indeed; yet I understand that it is a very common thing for a member after speaking—say for twenty minutes—to look at the clock, observe that he will not detain the meeting, as he knows there are others to follow, and go merrily on for another twenty minutes or more. I am aware that there must be considerable difficulty in dealing with this matter. Frequently a carefully prepared speech by an expert is of far more value than the paper itself; but again, I think it will be found that if some limit could be imposed, much padding might be avoided, and members would gradually learn the very valuable art of condensing their thoughts.

I would suggest, therefore, that it be within the discretion of the chairman to call the attention of the member who may be speaking, should he overstep a certain time limit, with the appearance of going on for still some time longer. Of course, in cases of this kind everything must depend on the tact of the chairman. Nothing is easier than to scatter the ideas of a speaker, especially if he be a nervous man, by an interruption; and it may often appear as though a chairman bore a grudge against a particular member if he should happen to have to call him to order very often. I think, however, that the matter may be safely left in the hands of the chairman. Further, I would suggest that no barefaced advertisements should be allowed under cover of discussion. A man's own experience, or his own thoughts, contributed for the benefit of himself and others, do good, and tend to the usefulness of the Institute; but a statement that he is the maker of so-and-so, or some-one else is the maker and his things are the best, unaccompanied by any real information that can forward the aim of the Institute, viz., the instruction of its members, should be strictly tabooed. I would also suggest that country members, when unable to attend, should be allowed and encouraged to send their remarks to the secretary, to be read at the meeting, or inserted in the transactions, as may be convenient.

I would also propose, for the consideration of the Council and the members generally, a measure that may possibly appear, at the first blush, somewhat revolutionary, viz., that ladies should be admitted to our meetings, and as members of the Institute.

It is well known that there are numbers of female workers in the electrical field, to many of whom I imagine attendance at our meetings would be a privilege and a boon, while the possession of our transactions would be to a large extent as valuable to them as to us. Electrical science is so many sided, and presents so many openings for female labour of every grade, that I feel sure increasing numbers of the opposite sex will find in it congenial and lucrative employment; and I think it can hardly be questioned that, if our Institute is of any value at all as an educational instrument, the admission of women to its privileges must tend to increase the chances open to them of obtaining lucrative employment.

I have no doubt that some one will reply that ladies do not want to come to our meetings. I am not at all sure that there may not even now be many who would be very glad of the privilege; but as we do not propose to force them to come, or to do anything beyond allowing them to come if they wish, I hardly see that the proposal is at all affected by any guess we may make on the subject. My own impression is that possibly, for a time, the privilege would be inoperative; then, when there happened to be a paper on in which ladies of advanced education take an interest, perhaps some members' wives or daughters might attend; and so it would go on till we came to look upon their attendance as a regular thing.

Someone else will, perhaps, object that we may get frivolous—society women invading our meetings, and disturbing the tranquility of our discussions. It is, of course, very difficult to forecast what stupid antics fashion may decree, and we know that women have, at fashion's bidding, gone through very much more terrible ordeals than sitting out a discussion at one of our meetings; but I do not think we should be in much danger of such an infliction.

To the frivolous ladies whom we do not want, and to whom our discussions would bring no benefit, they would

be dryer than a fashionable sermon, and though they may not know much of many things, they do know when they are bored, and have the sense to keep away from boredom.

But I have a very much stronger argument for the admission of women of all grades to our meetings. I think it must be known to everyone that the extension of electrical enterprise will entail the bringing of electrical apparatus of all kinds within the home circle. Now, in my opinion, one of the greatest difficulties which promoters of these enterprises will have to encounter will be the want of knowledge of the users—principally women. A long experience in bringing forward new forms of apparatus has taught me that where you have any one on the ground who either understands the apparatus, or will take sufficient interest in it to master it, you will attain success with comparatively inferior materials; while you will fail utterly with the very best that can be produced if there is no one about who will take any interest in the matter. And of all offenders in this respect women are at present, in the great majority of cases, by far the worst.

Firstly, because they know nothing of electricity; and

Secondly, because they will not think.

If we are to succeed in superseding gas and other apparatus for domestic use, it will be an immense gain to us if we can teach women to think, and, above all things, to think about electricity; and I maintain that admission to our Institute will be the means of inducing both. Once the wonderful fascination most of us feel for the science gets hold of women, they will go right on and do half our work for us.—Yours, &c.,

SYDNEY F. WALKER.

[With regard to one part of Mr. Walker's letter, we may say that it is becoming customary to send out proofs of the paper to be read to gentlemen named by the author, or by the council, as desirous of taking part in the discussion. Mr. Walker's criticism had better be directed against authors who do not send in their MSS. sufficiently early to allow of its being put into type and corrected. We venture to surmise the stumbling-block to the sending out of proofs as suggested is found at the feet of the author, and not elsewhere. Mr. Walker will, we are sure, understand that by making the above statement we have no desire to stop discussion; our object is to direct it towards the proper quarter. With regard to ladies at the meeting—we are open to conviction either way.—ED. *E. E.*]

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

[CORRECTION.—The following corrections should be made in Mr. Kapp's paper in our issue of last week:—On p. 136, instead of $e = \sqrt{E}$ and $i = \sqrt{I}$, it should be

$$e = \frac{E}{\sqrt{2}} \quad \text{and} \quad i = \frac{I}{\sqrt{2}}.$$

Also, in the formula for E the exponent is 8, not s—

$$E = 2 \pi n F \tau 10^{-8}.]$$

THE DISTRIBUTION OF ELECTRICITY BY MEANS OF SECONDARY GENERATORS OR TRANSFORMERS.*

BY J. KENNETH D. MACKENZIE, MEMBER.

One of the difficulties which arises in all transmissions of electrical energy is the conveyance of a current suitable at one and the same time for any and every class of receiver. Each receiver requires, in order to work under proper conditions, a current suitable to itself, which current must have the proper proportions of potential and quantity. Now, as it is necessary, when the factor of *distance* is brought in, to increase the potential of the current in order to overcome the resistance due to that distance, it follows that receivers cannot be used which are not capable of supporting the particular current necessary to work them at in increased distance. In the transmission of the current for glow lamps the distance is determined by the resistance of the lamps.

If it were a question what type of glow lamp is best, the reply would mainly be, that one whose resistance is the greatest—other considerations, of course, such as efficiency, being equal. Should it be necessary to convey current for lighting purposes over a radius of several miles, the resistance then incurred would no longer be in proportion to the E.M.F. necessary to be employed. Likewise, in the transport of power over a given distance, if each motor corresponded to a certain construction, it would be necessary to modify and vary each one, according to its position from the main source. Lastly, if it were a question of transmitting electric energy to work at the same time arc lamps, glow lamps and motors, the current suitable for one type of receiver would not be adapted for the others; in other words, according to the nature of the receiver employed, so must be also that of the current.

It was to overcome these most serious difficulties, which stood in the way of the practical development of electric lighting and transmission of power, that Messrs. Gaulard and Gibbs grasped the idea of interposing at the receiving point between the supply wire and the receivers a supplementary apparatus or generator, as a transformer of energy, which would deliver to the receiver

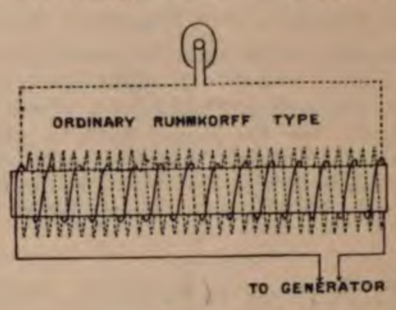


FIG. 1.

with which it was connected a current proper to such receiver. The secondary generators thus in a manner prepare and modify the current transmitted from the source, and give it the necessary proportions of potential and quantity which the particular receivers supplied by them require, in order to work at the highest point of efficiency.

This idea in itself was not new when M. Gaulard commenced his experiments, Jablochkoff, Fuller, Sawyer-Man, Sir Charles Bright, and many others having previously striven to bring the matter to a practical issue; but success did not crown their efforts, for the simple reason that the basis of all their experiments was the Ruhmkorff coil more or less modified; and it was only when M. Gaulard came to the conclusion that induction apparatus constructed upon the theory founded by Faraday, and exemplified by Ruhmkorff, was unsuited for the purpose, that a step was made in the right direction.

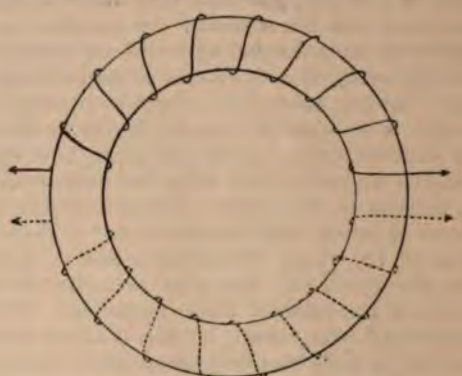


FIG. 2.—Faraday's Non-Polar Type.

The principles underlying transformers may be clearly seen by reference to Figs. 1, 2, 5, and 6, where what may be called the "Ruhmkorff and Faraday" type are shown, and the Gaulard type in Figs. 3 and 4.

In the figures illustrating this paper "primary" or *inducing* current wires are shown in *black*, and "secondary" or *induced* current wires by *dotted lines*.

In the Rhumkorff type the secondary is either superimposed upon the primary, as in Fig. 1, or it is wound upon a core distinctly separate from, though contiguous to, the primary, and is alone acted upon by the magnetic changes set up in the core, as in Figs. 2, 5, and 6. It is for present purposes immaterial whether the core is polar or non-polar. In the Gaulard type *the secondary is placed in an identical position in regard to the iron core with the primary*, and is thus acted upon both by the core and the primary or inducing circuit, as in Figs. 3 and 4. This is one of the two principal features wherein the Gaulard-Gibbs transformer differs from all previous ones, the other principal feature being that the metallic mass of

* Paper read at the Society of Telegraph-Engineers and Electricians, February 9th, 1888.

When Messrs. Gaulard and Gibbs first exhibited their system at the Westminster Aquarium, in the beginning of 1883, only one transformer was there shown at work, and this one was consequently either in parallel or series with the dynamo. The advantages that would have resulted were a series system of connection possible being so apparent, M. Gaulard inclined more to this method of working, and used his best endeavours towards arriving at a successful result. He knew the impossibility of directly maintaining a constant potential in a secondary circuit whose resistance was being varied whilst the current in the primary was kept constant (an essential feature in series working), and therefore strove so to construct his apparatus that the action of the core upon the two conductors should vary with the alterations of resistance in the secondary. This he did by altering the position or exposing more or less of the core, and some attempts were made to effect this automatically.

As has been before said, the value of the secondary circuit varies directly with the *square* of the current in the primary, and *directly* with the number of turns; other considerations, such as the magnetic influence of the core and the number of current alternations, being constant.

The E.M.F. of a secondary circuit, however, is dependent upon another important factor, namely, the resistance to which it is opposed; and the following table of experiments made by M. Uzel, and published by Professor Galileo Ferarris in his report to the Jurors of the Turin International Exhibition, 1885, shows the increase of secondary E.M.F. with increase of resistance. It will be observed that the current in the secondary falls at the same time.

PRIMARY.		SECONDARY.		
A.	V.	A^1.	V^1.	R.
12·13	23·4	12·02	15·0	1·24
,,	31·4	12·0	24·0	2·0
,,	53·0	11·83	45·0	3·8
,,	70·0	11·73	65·0	5·5
,,	93·0	11·58	87·0	7·53
,,	107·0	11·3	102·0	9·0
,,	126·0	11·13	119·0	10·6
,,	144·0	10·95	138·0	12·6

where A = amperes in primary, V = potential at poles of generator primary, A^1 = amperes in secondary, V^1 = potential at poles of secondary, R = resistance in ohms of the outer part of the secondary circuit.

It will thus be seen that the resistance in the secondary forms an all-important factor when designing apparatus for producing a required result; and a long series of experiments has established a certain ratio to be observed in order to obtain the effect sought for.

Experimentally it was found that with a certain current in the primary circuit of a given number of spirals or turns a certain electro-motive force was obtained in the secondary with a given resistance, and upon these data the construction and design of apparatus employed as series transformers were based.

The work done by the primary current when traversing a number of generators is proportional to the resistance offered by these generators, or, in other words, by the counter E.M.F. opposed to the primary current by the secondaries. This necessarily is proportional to the number in use, and also proportional to the individual resistance of each secondary.

It can therefore be seen that the total energy of the primary current varies directly with the amount of work done by the secondary circuits of the generators, thus enabling complete economy in working to be obtained.

The economy resulting from this system of working in series would be substantial were it also possible to ensure constancy of potential at the same time between the poles of the secondary with a varying resistance in that circuit. The difficulty is that the E.M.F. increases in the same ratio as with the resistance; and this, consequently, points to the fact that transformers, when connected in series, must supply lamps also in series, or, in other words, the external secondary circuit must diminish in resistance as the lamps are turned out, instead of increasing, as is the case when the lamps are in parallel. More than two years ago I made some experiments upon this subject with Mr. Bernstein, the results being perfectly satisfactory so far as regulation went. Another way out of the difficulty, if series transformers and lamps in parallel are to be used, is by the employment of subsidiary resistances, or "choking coils," as they are called, which take the place of the lamps when turned off. Fig. 9 shows this in a theoretical diagram.

With series transformers and series lamps, all danger from fire risk is reduced to a minimum. No main fusible cut-out at the transformer secondary poles need be used; for, as has been before said, if a short-circuit occurs, the potential immediately drops, so that the flow of current is consequently that due to the resistance of the secondary helix, including the short-circuit. I have frequently run series transformers on short-circuit, and no heating has resulted, the potential at the terminals being imperceptible on a voltmeter, whilst the current indicated by an ammeter in the short-circuit was solely that due to the resistance of the ammeter and the secondary circuit of the transformer itself.

Another difficulty that lies in the way of working transformers in series is that experienced in maintaining a constant current on the line; and although many attempts have been made to do this automatically whilst employing alternating-current machines, no great success has as yet been attained.

Having briefly reviewed the system of working transformers in series, and shown the objections inherent to that method, I will now refer to the parallel system—upon which all present installations are based—treating the subject in as practical a manner as possible.

At the outset one important feature, inseparable from all parallel systems of transmission of energy, may be mentioned, especially since it shows how, by the use of transformers, difficulties may easily be surmounted.

This is that the fall of potential along a line varies in proportion as the current is increased when changes are made in the load. The difference of potential between the source of supply and the extremity of the line is small when the current is small, but very considerable when a heavy current is used; and consequently, if the lamps near to the source be kept at a constant pressure, those far off will vary according to the intermediate load. In direct working this objection can only be met by employing a conductor of such size as will render the resistance of that conductor of no account, but then all considerations of economy will have to be abandoned.

This difficulty has been experienced in all large direct-supply works, since the fall of potential depends upon the ratio that the amount of loss on the line itself bears to the maximum amount of work carried by the line, this in many cases being quite 20 per cent. By employing a high potential, however, the current to represent a given amount of energy may be so reduced that this ratio may be made as low as 1 per cent. per mile; and consequently transformers in parallel are capable of maintaining practically the same potential in their secondary

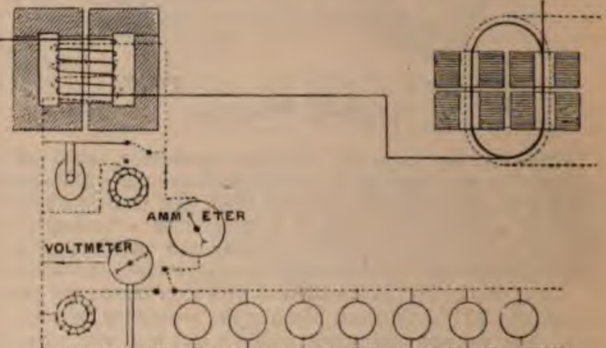


FIG. 9.—Series Transformer Choking Coils.

circuits, irrespective of their position upon the line, or of the variation of the load at intermediate points. The following figures may make this matter clear:—

Suppose a dynamo giving an output of 150,000 watts, equal to, say 1,500 amperes and 100 volts. If the conductor be proportioned so that one square inch of sectional area be used for every 1,000 amperes, the size of the conductor necessary will be 1·5 square inches. This conductor having a resistance of about ·028 ohms per mile (neglecting heat resistance), the loss per mile on the line will be $1{,}500^2 \times {\cdot}028$, or 63,000 watts—equal to about 42 per cent. of the total output of the dynamo per mile.

By the use of transformers, however, the same energy could be transmitted over the same distance with a very different percentage of loss. The output, being 150,000 watts, may be represented by a current of 50 amperes and 3,000 volts. The resistance of a cable required to carry this current, calculated on the same basis, would be about ·864 ohms per mile, and the loss, therefore, would be $50^2 \times {\cdot}864$, or 2,150 watts—equal to about 1·4 per cent. of the total load per mile.

These figures merely serve to show one of the enormous advantages that are reaped by the employment of transformers in the distribution of large amounts of electricity over great distances.

With regard, now, to the practical working out of a system of supply based upon parallel transformers, I will endeavour to show what has hitherto been done, the methods employed, and the results obtained.

The dynamo here claims our first attention, and, being the generating source of supply, forms, perhaps, the main feature in an electrical installation. In the first place, it must necessarily be of what is known as the alternating type. Up to very lately

this class of machine had in this country received but a small amount of attention; now, however, since the transformer system has become known and appreciated, several makers have gone into the subject, and many marked improvements have resulted. One of the chief of these is the employment of iron in the armature, and such good results have been obtained by making the mass of iron very considerable in both armature and field, that this plan is now regularly adopted. One of the most important points in this class of machine is self-regulation, more especially with regard to small variations in potential; the changes of load occurring on a supply system, which produce extensive alterations in the external resistanee of the circuit, and consequently large variations in potential, being easily met in other ways, such as by the introduction, either automatically or by hand, of resistances into the exciting circuit, or by varying the speed of the machine itself. As much as 2 volts per foot of wire may be obtained from the armature of a dynamo without any very considerable speed; and it is of importance to get this amount, if not more, when we remember that the magnetising effect of the current in the armature coils, as well as the amount of self-induction, is proportional to the number of turns in the coils.

Now, since both are objectionable when amounting to much, high E.M.F. and steadiness of potential may be obtained by greatly increasing the mass of iron, so that half saturation is never exceeded. Some very large alternating-current dynamos are now in use in this country, probably the largest being those by Ferranti, employed at the Grosvenor Gallery Central Station. Others, by the same maker also, are now in hand for the new supply works of the London Electric Supply Corporation, Limited, at Deptford, whose dimensions appear rather formidable. Their armature are to be, I understand, about 42ft. in diameter, and will be driven direct from quadruple expansion compound surface-condensing engines of a marine type, indicating 5,000 h.-p. each.

A type of alternating-current dynamo is shown in Figs. 10 and 11, which, though founded on a system previously known and patented, has lately been altered so as to render it workable and efficient by Mr. Kingdon, who, early in 1886, submitted to me his ideas upon the subject. Those who had previously worked in the same direction had failed to make a serviceable machine from having overlooked the importance of laminating all the iron acted upon electrically, as well as other minor details requisite to make the idea practicable.

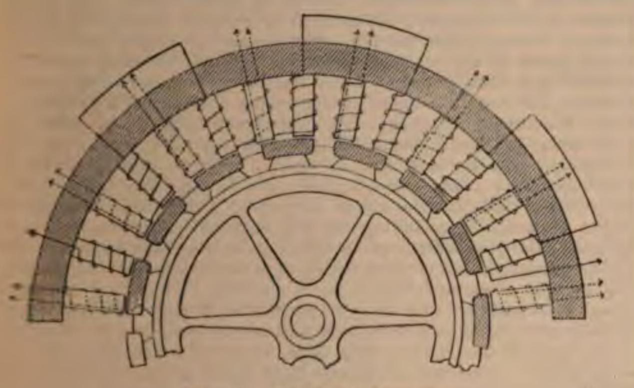


FIG. 10.—Kingdon's Dynamo.

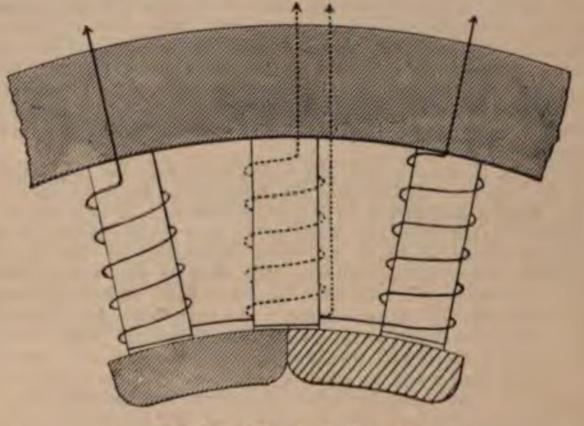


FIG. 11.—Kingdon's Dynamo.

A series of bobbins, whose cores form parts of one whole continuous iron structure made of laminated soft iron plates, are divided into two divisions: one of these is rendered magnetic by separate excitation, and is shown in the figure by black lines; the other, as shown by dotted lines, is acted upon inductively by the revolving laminated inductors, which may form part of the fly-wheel of an engine. It will be seen that if the black bobbins be coupled up and excited they will each have an alternate polarity, and that if an iron armature or inductor be placed across the pole of one of these bobbins and the pole of the next non-excited bobbin, a current will be set up in the wire forming this second bobbin, which current will tend to make its core of an opposite polarity to the one next it, and which is joined with it by the inductor. As the revolving inductor alternately connects the induced bobbin with its neighbours, each of which has an opposite polarity, it follows necessarily that the current that will flow in the induced bobbin will be alternating.

I would draw your attention here to one striking feature in this machine, viz., that the same mass of iron serves both for the field magnets and the secondary coils, these all being, so to speak, prolongations or teeth of the iron mass. A series of alternate bobbins, excited and not excited, if magnetically connected in this manner by revolving inductors, will yield a current from those bobbins not separately excited, which current will depend for its value upon the strength of the magnetic field due to the excited bobbins, the size of the induced bobbins, the quantity and dimension of the wire thereon, and the speed at which the inductors revolve.

Experiments made with a dynamo of this nature have so far given very good results, some of the main advantages that may be claimed for such a type of generator being that there is no revolving or moving wire, no collectors and consequently loose contacts; that the machine may be divided into separate circuits, which, by means of a switch-board, can be easily varied; and, lastly, that very great simplicity of construction, and consequent low cost, is obtained. The fly-wheel of the engine may carry the inductors, and as this can easily be made of very great size, slow-running machinery may be employed, with its consequent advantages.

In designing supply works for electric lighting on a large scale, I am of opinion that the employment of a few very large dynamos, instead of a larger number of smaller ones, is a mistake, and that, generally speaking, the output from each dynamo should not exceed 10 per cent. of the total capacity of that particular station. In all running machinery, be as careful as one may, accidents will happen; hot bearings will, when least expected, occur; and with a heavy load on an engine running under such conditions serious damage may be caused, whilst, if a stoppage be made, a very heavy proportion of the total output will be affected. It is true that with a larger number of small engines the initial cost is greater, the depreciation greater, maintenance and attendance more costly; but, nevertheless, I am inclined to think that these disadvantages are more than counterbalanced by the greater security gained in subdividing the producing plant to a larger extent, especially when it is remembered how important it is in works of this nature that no breakdown in the supply should occur.

It may be well to remark here that it has been found quite practicable to couple alternating-current machines in parallel, so as to throw them in and out of circuit whilst current is on the line. Messrs. Zipernowski effected this some while ago, and I find that the Westinghouse Electric Company also work their machines thus. Practically speaking, all that is necessary is to synchronise the dynamos, and whilst their alternations are thus synchronous they can be coupled together or disconnected at will.

I cannot speak from much experience myself on this subject, having only experimented with some of Messrs. Siemens' machines. I found, however, that whilst it *was* possible to synchronise them and couple them in parallel, yet the slightest thing would throw them out of gear, if I may so speak, and destroy the balance. Even a small piece of waste falling on the belt was sufficient to do this.

With dynamos, however, having a large mass of iron in the armature, I believe it to be much more easy to couple them together, and this may be the reason why others have had more success than myself. The subject is an interesting one, and of great importance, I think, in large central stations employing alternating currents and transformers.

Until some practical means of electric storage, suitable for installations of this nature, be devised, the whole question of electrical distribution cannot be said to be completely solved. In gasworks plant can be laid down which will continually produce gas, which can be stored and drawn upon during the few hours in which the demand is greatest; but with electric lighting, if carried out on a large scale upon this system, it is necessary to furnish plant capaple of meeting the maximum demand, although such demand may only exist during one hour in the twenty-four. This necessitates the machinery standing idle during a part of the day, and consequently loss through unprofitable employment of capital; hence it is most essential that due care and forethought be exercised in arranging the number and sizes of engines and dynamos in any specific installation.

(To be continued.)

BOOKS RECEIVED.

"Electrical Instrument Making for Amateurs," by G. S. R. Bottone. Whittaker and Co. Price 3s.

"Berly's Universal Electrical Directory." A complete record of all the industries directly or indirectly connected with electricity and magnetism, and the names and addresses of manufacturers in Great Britain, America, the Continent, &c. Dawson and Sons. Price 6s.

"Accidents in Mines," by Sir F. A. Abel, C.B., with an abstract of the discussion upon the paper, edited by James Forrest, Sec., being excerpt minutes of proceedings of the Institution of Civil Engineers.

LEGAL INTELLIGENCE.

CRAMPTON v. SWETE AND MAIN.

On the 11th inst. judgment was given in this case by Mr. Justice Kekewich. Briefly the plaintiff, Mr. T. P. C. Crampton, was a working electrical engineer, his business consisting almost entirely of the manufacture of electric bells according to an invention for which he obtained provisional protection on the 2nd of February, 1886. In the present action he seeks to restrain the publication by the defendants (who are electrical engineers of 11, Queen Victoria-street, E.C.) of the following circular, which he alleges to be false and malicious and in effect a trade libel:—"Mansion House-chambers, 11, Queen Victoria-street, London, E.C., October 7, 1886. Messrs. Sweete and Main beg to inform you that they are unable to supply under any circumstances the Crampton patent bell, as this bell has proved to be an infringement of the Jensen bell. Such bells as have been sold to you by Messrs. Swete and Main are exempt from an action for infringement by Mr. Jensen, the royalty moneys having been paid thereon by Messrs. Swete and Main." The plaintiff's contention was that the circulars imputed that the plaintiff's bells had been proved in a court of justice to infringe the Jensen bell. As a matter of fact, there was no action pending against the plaintiff at the time when the circular was issued. An action had subsequently been commenced against him for infringement by the Patents Investments Company, to whom the Jensen bell patent has been assigned, but this action is still pending and is being defended by the plaintiff.

Mr. C. E. E. Jenkins and Mr. C. H. Tylee were for the plaintiff; and Mr. Roger W. Wallace and Mr. Williams for the defendants.

Mr. Justice Kekewich, in delivering judgment, said the case of the plaintiff was that Swete and Main had by issuing the circulars to their customers (some of whom had been introduced by the plaintiff) practically destroyed his business. The circular was wrong until it could be proved to be innocent by being shown to have been issued with reasonable and probable cause. The defendants had referred to Section 32 of the Patent Designs and Trade Marks Act, 1883; but that had as much to do with this case as any other section of any other Act. Something must be necessary to show that the words, "have been proved," were properly used. "Proved" meant established. At this time the defendants did not know that any litigation was pending. The statement, though the defendants did not mean to do wrong, was untrue; and the plaintiff had thereby suffered damage, which his lordship assessed at £20. The defendants counter-claimed for damages for misrepresentations, but this claim failed. They also claimed for the price of a lamp. The plaintiff must return the lamp on payment of 11s. 6d., but the defendants must pay the costs.

COMPANIES' MEETINGS.

TAUNTON ELECTRIC LIGHTING COMPANY (LIMITED).

The first annual general meeting of the shareholders of the Taunton Electric Lighting Company (Limited), was held last week at the CastleHotel, under the presidency of Mr. W. H. Fowler, chairman of the board of directors.

The **Chairman** read the report, which was as follows:—"Your directors have pleasure in presenting herewith the first annual report of the Company. The number of shares allotted is 873, on which the sum of £4,365 has been received, including the amount allotted on account of the purchase of the business. The number of private customers is now 20, besides the town lighting, and the number of arc lamps let at a rental is 65, besides the incandescent lamps in use, numbering 200. The accounts for the year show a profit of £315 15s. 5d. Your directors recommend that a dividend of 5 per cent. be paid free of income-tax. This will take £191 19s. 6d., leaving a balance of £123 15s. 11d. to be carried on for a reserve and depreciation account. In addition to the Taunton business the Company has carried out temporary installations in Bath, Weston-super-Mare and Exeter. Deputations from various places have visited Taunton during the past year for the purpose of inspecting the Company's works, machinery, and the lighting arrangements of the town, the general testimony being that it is one of the most successful installations yet carried out in the United Kingdom. The machinery has been maintained in excellent working order, those portions of it which are continuously wearing out being made good, and charged to income account. As the demand for the light increases, it is expedient to lay down more plant and machinery, and to enable the directors to do this they hope that the public generally will take up more shares to increase the capital available for this purpose. Two of the directors retire by rotation, and are eligible for re-election. The names of the retiring directors (to be decided by ballot) will be announced at the annual meeting. The auditor, Mr. Albert Goodman, retires, but is eligible for re-election, and offers himself accordingly."

The **Chairman** then moved: "That the report of the directors and statement of account be received and adopted, and a dividend of 5 per cent. per annum, free of income-tax, be declared payable on and after the 13th instant." He remarked that it was his pleasing duty to have to propose the adoption of the report at the end of the first year of the existence of the Taunton Electric Lighting Company. They must all consider it a very satisfactory matter that they had been able, in spite of the many difficulties that stood in their way, to show that electric lighting could be made pay, and to declare a dividend of 5 per cent., which they had fairly earned. It was very necessary for the well-being of the Company that the capital should be considerably increased, and they had reason to hope that in the immediate future a sum of at least £1,500 would be forthcoming, which would enable them to extend their sphere of usefulness to a large extent. He hoped that in the future they would also be able to pay a better dividend than that which they were able to announce that night. They had to pay a large sum for the exclusive right to use the Thomson-Houston system in Taunton, which, of course, would always remain; but the larger the amount of work they did the better it would be, as far as their dividends were concerned. A ballot had been taken to decide the order in which the directors should retire, with the result that Mr. Samson and Mr. Lewis would retire in 1888; Mr. Bale and Mr. Withycombe in 1889; Mr. Potter and himself in 1890.

Mr. W. Potter had very great pleasure in seconding the resolution. He was sure it was a matter of congratulation to the directors to see the shareholders so well represented that night. At some annual meetings which he attended the shareholders were conspicuous by their absence, and the whole business of reading and adopting the report and passing resolutions—including votes of thanks to the directors—devolved upon the directors themselves. On such occasions the directors flattered themselves that it was a proof that they enjoyed the confidence of the shareholders, but he knew that when the shareholders attended the annual meeting in large numbers it was more satisfactory to the directors, because it showed that they felt an interest in the Company's affairs, and it gave an opportunity for discussion, during which valuable suggestions were often made which might prove of the greatest usefulness. They would all agree with the chairman that the report which had been read was a very gratifying one, not merely because it declared a dividend of 5 per cent. on their investment, because that was secured to them from the very first by their managing director as the vendor to the Company, but because the Company in the first year of its existence had made such profit as to justify the directors in declaring that dividend out of the actual profits made during the year. It would be gratifying not only to the shareholders, but to the general public, inasmuch as it would go a long way to secure that public confidence and support which were so essential to the commercial success of an undertaking such as that. They had met with people who professed very much to admire the electric light and wished it every success, but who were reluctant to take shares in the Company until they saw that it was going to be a financial success. The fact was, public confidence in electric lighting as a commercial success sustained a shock by the collapse of the companies formed some years ago. Electric lighting seemed to him to have been prematurely thrust upon the public. It had many imperfections, and was produced at very great cost, and the consequence was that it proved disastrous to those who invested in it; but within the past few years very great improvement had been made in electric lighting, and its production now was far less costly than it was then. It seemed to him that it had at the present time all the elements of commercial success, and it was, as they knew, rapidly rising in public estimation and confidence, and there was every reason to believe that the failures of the past would prove the precursors of its future success. He need not tell them that the electric light had brought the town into notice in a manner nothing else had ever done. It had been a most effectual advertisement to the town, and it had undoubtedly brought increased trade into it, in which all classes of the community must participate. There was not the slightest doubt that by means of the electric light the town had been so advertised that many who before were altogether ignorant of the existence of such a place as Taunton, or if they did know anything of it, regarded it as a writer in the *Daily Telegraph* did a few years ago, as "a village in the West of England," now, by means of the electric light, knew it as an enterprising town, beautifully situated and possessing many residential attractions. He thought they might confidently expect that still greater benefits would accrue to the town as a result of their enterprise in that respect. Such being the case, and he was convinced that it was so, it seemed to him that it was the duty of the trading portion of the town especially to interest themselves more in this matter than they had done hitherto, and to do everything they could to make the electric light a success, and also to share some portion of the responsibility. That, it must be confessed, had not been done to the extent it was hoped and expected it would be. The responsibility and burden had been left in the hands of a few who had had to push the thing not only against indifference but determined opposition. That the introduction of the electric light into Taunton would be met with opposition was well known. The directors knew perfectly well they would have opposition to contend with, and they were prepared for it. They had the light of history to teach them in that matter—that opposition attended the inauguration of every new movement. However beneficial it might be to mankind it was always assailed with opposition, springing from two sources—the first from indifference, and the second from mistrust of anything that

had not proved itself to be an established success. People moved in the old ruts, and thought on the old lines, and regarded with aversion anything likely to contradict their pre-conceived notions or falsify their theories. In addition to this there was always opposition arising from vested interests. It was an omni-present obstacle to all improvements. People objected to companies because they would touch some one in the sensitive part of his nature, viz., his pocket. The opposition they had to contend with the shareholders knew had been very great, and possibly it might be traced to one or other of these reasons. They knew that some measures which were now admitted to be of incalulable benefit to the human race were at first met with determined opposition. He thought this explained the damaging statements that had been made with reference to the electric light. It was just the same when railroads and machinery in agricultural and manufacturing industries were first introduced; the inventors and promoters were assailed with very harsh language and treated in a very unkind and ungenerous manner, simply because it entrenched on someone's pocket, or in some way or other interfered with the employment of the few, although by the starting of those new industries employment was given to the many; whilst the profits of the few were curtailed the whole nation was enriched. The very same opposition that was manifested towards the introduction of railroads and steam power was now persistently shown against this new illuminant. The fact was there were many who were afraid that if the electric light proved a success the result would be a lower rate of dividend in the gas shares, but why this should be so he did not know. If it were true, and he had no doubt it was, because he had been told it on the testimony of those in whose veracity he had the fullest confidence, that street lighting did not pay the Gas Company, and that the directors of the Gas Company were glad they had the electric light in the streets, then they might reasonably expect to find in the directors and shareholders of the Gas Company their warmest friends and advocates of the new light. But it was not so; they found that some of the most damaging statements that were likely to affect the credit of the Electric Lighting Company and prejudice the minds of the Company against the light had emanated mainly from those who had been holders of gas shares. Fortunately some of the statements that had been made were so palpably absurd that they had not required any refutation from the Company—they had carried their own refutation in their absurdities. For instance, they were told that the electric light, instead of being what it professed to be—viz., 1,200 candle power, was only 200. He admitted he had too high an opinion of the gentleman who made that statement to suppose that for one moment he believed it. He would not insult his intelligence by supposing that he believed the lamps only gave 200 candle power instead of 1,200; but in such a statement they had a striking instance of man voluntarily degrading his intelligence for the sake of his pocket. Other statements were that the installation was very costly, that it would not last more than three years, and that the atmospheric influences were such that at the end of three years the present wires would be useless. That was a very serious matter, and one which affected them so vitally that he had not merely ascertained the opinion of their own electrician upon it, but he had mentioned it to a gentleman of repute who had no connection whatever with that Company. They both assured him that such a statement was an absolute fallacy, and that it was void of any foundation in fact. They were told not merely by their opponents, but by those who were favourable to the light, that it was not so good as it was. They heard that on every hand, but their electrician and those who knew said that a probable explanation was to be found in the fact that they had now got accustomed to the light, and they knew the old adage that "familiarity breeds contempt." He mentioned this to the electrician whom he had referred to, and he said, "Yes, it is always the way. I will give you an instance. A short time ago I fitted up a large factory at Nottingham, a factory employing some 1,500 hands. People were charmed with the light; it went on satisfactorily for some months, and then they said it was not so good as it was formerly, and they made a great many complaints. The proprietors of the factory said, 'We will turn on the gas again.' They did so, and the result was that the whole mass of people rose and said they would not work by such light, and unless the electric light was restored they would go out on strike." The electrician in question also assured him that in his experience he had found it over and over again that after a time people became accustomed to the light and said it was not so good. The present installation might not be perfect; they did not claim perfection for it. It might be, in comparison to the light that science should evolve in the future, as imperfect as the crude engines of Stephenson were to the powerful engines which they saw every day at the railway station—the Zulu and the Flying Dutchman—or it might be that the present system of lighting was as crude and imperfect in comparison with that which might yet be perfected as the "spinning Jenny" of Arkwright was to the splendid pieces of mechanism which might be seen any day in our cotton manufactories, and which, from the splendid manner they performed their work, seemed to be almost instinct with life and intelligence. The directors, in the future, would not pursue a policy of inactivity. Any improvement that could be effected by which more light could be secured or the position of the Company enhanced would be adopted by them, in the hope that if they were not, like the American companies, able to declare a dividend of from 8 to 16 per cent., they would year by year be able to declare a dividend of at least 5 per cent., and so merit their confidence and support.

The resolution was carried.

Mr. Samson and Mr. A. Lewis were re-elected directors. Capt. Winter and Mr. C. E. Lance were also elected on the directorate, bringing the total number of the directors to nine. Mr. Massingham was re-elected managing-director.

In proposing his re-election, **Mr. J. H. Bale** stated that the success of the company had been largely due to Mr. Massingham's able management.

Mr. Massingham, in returning thanks, said it was a great pleasure to occupy the post, because he took a keen interest in the lights of the future. He was pleased that the prophecies which had been made about them at various times had proved to be false. They were expected to come financially and technically to disaster, but they had proved a success, showing that it was not always wise to prophecy unless they knew.

The **Chairman** said that Mr. Wharton, a member of the firm of Messrs. Laing, Wharton, and Down, was present, and no doubt the meeting would like to hear him upon the subject.

Mr. Wharton congratulated the shareholders on the very satisfactory result which had been arrived at on the year's working. The name of Taunton would be very much advertised from that night forward. It would go throughout the length and breadth of the country that the Taunton Electric Lighting Company had declared a dividend of 5 per cent., which was unique in the annals of electric lighting. Taunton was the pioneer installation in this country, a sound commercial installation on the American system. Central stations had been started in various other towns in the country, but they had not been a success themselves. In Brighton, Eastbourne and Hastings central stations were started some years ago, and very large sums of money had been spent, running into hundreds of thousands of pounds, and the result commercially was almost *nil*. He was glad to say that Taunton, which was the first town in the country to adopt the Thomson-Houston system, was the first town to possess an electric lighting company of their own which was financially and technically a success. The following appeared in the electrical papers recently:—"The second meeting of the Electric Lighting Committee of the Bath Town Council took place on Thursday, at the Guildhall. The chairman said he had much pleasure in laying before the committee the information asked for at the last meeting. With a view to obtaining it from the most reliable and independent sources, he had written to the scientific and technical papers devoted to electrical engineering, asking in what towns in the United Kingdom the electric light had been adopted, and in what places it had proved succesful, or been abandoned. After a long discussion it was pointed out that all agreed that the most successful installation was the one at Taunton, and the town clerk was requested to put himself in communication with the town clerk of that town, and ascertain particulars respecting the system in use there, and report the result of his enquiries at the next meeting." Speaking of the success of the firm he said that the total number of Thomson-Houston arc lamps running in the United States was 50,000, and there were over 300 local companies like theirs at Taunton, all earning good dividends. The total number of incandescent lamps erected last year was over 200,000. Negotiations were nearly completed for nearly half a dozen such plants as that at Taunton, and the Midland Railway Company had decided to use the Thomson-Houston system for lighting St. Pancras Station. The Company had investigated all the systems, but hitherto they had maintained electric lighting was not complete enough for their purpose. If this experiment succeeded the light would be used on other parts of their system, and the London and North-Western Railway Company might probably follow suit.

The proceedings then terminated.

SUBMARINE TELEGRAPH COMPANY.

The half-yearly general meeting of the Submarine Telegraph Company was held on Tuesday at the offices, Throgmorton-avenue.

The **Hon. H. R. Brand** presided, and, having apologised for the absence of Sir J. Goldsmid, M.P. (the chairman of the Company), who is abroad, stated that the directors had asked him to preside because he had been associated with the chairman in negotiations with the English Government on matters seriously affecting the interests of the Company. The accounts were very simple, the only item calling for remark, perhaps, being the considerable increase in salaries and wages. The moiety of that increase was explained by the fact that there had been 27 pay-days in the half-year while the takings had been for only 26 weeks. The balance of the increase was explained by the necessary growth of the salaries. Their business had been subject to very little fluctuation. The accounts enabled the directors to recommend a dividend at the rate of 15½ per cent. per annum, to allocate the usual amount to the reserve fund, and to carry forward a small increase. He was quite sure, however, that their minds were occupied with the matters which affected the existence of the Company, and therefore he would inform them of the position with reference to the renewal of the Company's concessions. At two or three of their last meetings the chairman had deprecated any discussion on that question, and it was obvious that no advantage could be gained by making public the course of their negotiations with the French Government. At the same time, the chairman, in guarded language, expressed his belief that they would be successful in obtaining a renewal of their concession from the French Government. The chairman was perfectly justified in that. They had actually received an intimation from the French Government, of which M. Rouvier was Premier, that the renewal of the concession would be granted by that Government for a period of years on terms agreed on between them and the Company, when the English Government interposed and requested the French Minister to defer signing the agreement until he had had the opportunity of considering the alternative policy of the English Government to place the administration and working of the cables between England and Belgium and England and France in the hands of the Governments of the respective countries. For bringing about the success of the Company so far with the French Goverment, their chairman and Sir James Carmichael were to be thanked, and they were ably seconded by Count Dillon in Paris. He considered, and the directors considered that the action of the English Government was a breach of faith with the Company. They had pressed that point on the Government, but Governments had no conscience. If it were said that what proposed

was for the public advantage, something might be said for the policy; but it was not, he maintained, for the public advantage. The public could obtain every advantage from the Company that the Post Office could give them. It was a mistake to suppose that the tariffs had been settled by the Company; they had been settled with the Goverments by agreement with the Company. The action of the Government was not likely to stimulate and encourage private enterprise. Their former chairman (the late Sir James Carmichael) and the other concessionaires were the pioneers of submarine telegraphy in this country. He had said that what was proposed was a gross breach of faith by the English Government, and he would tell them why. In 1868, when the Government purchased the inland telegraphs, the Company entered into a working agreement with the Government for the transmission of messages along the inland lines. Ten years later the Government, being desirous of getting better terms, entered into a fresh agreement with the Company, by which, on the one hand, the Government invited the Company to obtain a renewal of the concessions from the French and Belgian Governments; and, on the other hand, the Company undertook, so soon as they obtained such renewal, to give terms to the Post Office more advantageous than those which had been fixed by the agreement of 1868. The Government now alleged that that agreement had become null and void by the failure of the directors to obtain an earlier renewal of its concession from the French Government and by lapse of time. Their failure to obtain an earlier renewal of the concession from the French Government had not been owing to any fault on the part of the Board, but to the fact that they were always met by the refusal of that Government to enter on a consideration of the matter until the expiry of the whole concession had arrived. But apart from that, the lapse of time and the failure of the directors to obtain an earlier renewal of the concession formed no justification for the action of the English Government. They entered into an agreement with the Company in 1878, and invited the Company to obtain a renewal of the concession from the French Government; and from that time until last November they had never intimated to the Company that not only in their opinion was the agreement cancelled, but that they intended to oppose actively the renewal of their concessions. They had urged that the Government ought to have regard to the circumstances he had mentioned in fixing the price to be paid for the Company's undertaking. There remained, however, the decision of the French Government, and also the question of the decision of the English Parliament. For his part he hoped that some effort would be made to point out the danger of the extension of Government business. If their undertaking were bought up, he was not very sanguine that the terms would be such as the shareholders and the directors would consider highly satisfactory; but he was happy to say that they had got the Government to assent to two principles for which the Board had contended, and to which they attached the utmost importance, but respecting which he would say no more at present. He concluded by moving the adoption of the report.

The **Hon. Ashley Ponsonby** seconded the motion.

Mr. King said he still hoped they would have justice done to them by the British Government, but if not they must go to the Court of Appeal and to Parliament.

Mr. Soden spoke of the danger which, in his opinion, the taxpayers incurred by the Government embarking in risks and responsibilities with foreign Governments in order to acquire the submarine telegraphs. The Government had arbitrarily intimated their intention to revoke the license which the Company had held for 30 years for the use of the foreshore. Every other submarine cable company carrying on business between this country and any other part of the world might at any time receive a similar intimation from the Government, and he, therefore, urged the advisability of the various companies combining. If the Government had paid too dearly for the inland telegraphs, that was no reason why they should now try and commit an act of injustice.

The **Chairman** put the motion, which was carried, and the dividend recommended was afterwards approved.

COMPANIES' REPORTS.

THE SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).

Fifth annual report of the directors, to be presented at the ordinary general meeting of the Company, to be held at the Cannon-street Hotel, London, on Tuesday, 28th February, 1888, at 12 noon:—

The accounts which are herewith presented to the shareholders are for the year ending 30th September, 1887. The business has grown, and has resulted, after paying all current charges and making fair allowance for depreciation of plant and machinery, in leaving a sum of £7,554 11s., which the directors recommend shall be applied to the writing off of £5 834 3s. 1d., the amount which stands against profit and loss, carrying forward £1,720 7s. 11d. The directors have resumed negotiations with the Compagnie Continentale Edison, with a view of arriving at an equitable settlement in the countries in which they hold patents in connection with electric lamps. Should these negotiations result in any plan which the directors regard as beneficial for the Company, they will call a special meeting of the shareholders. In their last report the directors stated that they were led to believe that a decision in the patent suit would shortly be given by the judges in the Court in Berlin. The case has dragged on during the year, but judgment has not yet been delivered. Competition is very keen on the Continent, but the Swan lamp is undoubtedly the best in the market. The sales have increased during the year considerably, and the demand for lamps during the winter months has been largely in *excess of* previous years.

THE BRIGHTON ELECTRIC LIGHT COMPANY (LIMITED).

Second annual report of the Brighton Electric Light Company's operations for the fifteen months ended 31st December, 1887:—

The directors have pleasure in submitting to the shareholders the report of the operations of the company from the 1st October, 1886, to the 31st December, 1887. The capital account has, during this period, been augmented by the sum of £2,100, which has enabled the company to increase their engine power and dynamo capacity, and to largely extend the circuits. The profit and loss account, after writing off the special legal expenses of the year, and an ample sum for depreciation of plant, shows a balance of profit for the fifteen months of £721 16s. 6d., which, with the small balance brought forward from last year's accounts, makes the sum to the credit of profit and loss account £729 0s. 11d., and the directors recommend the following appropriation of it:—

	£	s.	d.
Dividend of 5 per cent. per annum on the share capital ...	£568	16	10
Liquidation of the balance of the preliminary expenses account.....	89	16	2
Carried forward to next year's profit and loss account......	70	7	11
	£729	0	11

There has been a steady increase in the Company's business during the period under review. The mains belonging to the Company now extend a distance of 15 miles, reaching westward as far as King's Gardens, Hove; eastward as far as Eastern-terrace, Kemp Town; and northward as far as Hanover-crescent, Lewes-road. One reason of this increase of business, and of the probability of its further development, is the extension of the Company's mains into Hove. As that district consists almost entirely of the residences of the wealthy, a practically unlimited field is thereby opened to the company. The directors have considered it desirable, in order to be in a position to cope with their increasing business, to still further increase the dynamo power, to extend the company's circuits, and to gradually place "convertors" in all the premises lighted, by means of which it will be possible to turn lights on and off one by one when required. The cost of the proposed extensions will be about £2,000, and the directors propose to cover this sum by a further issue of share capital. Preference will be given to applications received from residents in Brighton and Hove, especially from those who are customers of the Company, as the directors are anxious to widen the local interest in the concern. The contemplated addition to the plant will bring up the total dynamo capacity to over 2,500 sixteen candle-power incandescent lamps, the present engine power being capable of driving dynamos for 3,500 lamps, so that the capacity of the plant can be enlarged to this extent by the addition of new dynamos at any time when required. The nature of the improvement in the company's business may be seen by the following statements:—

Lights in operation on—	Arcs.	Incandescents.
October 1st, 1885	34	516
,, ,, 1886	27	875
Decmber 31st, 1887	34	1,372

Quantities of electricity supplied from the works during the past fifteen months, as compared with corresponding months of previous year:—

	Units supplied.		
1886.	In former period.	In present period.	Percentage of increase.
October	1,269	2,633	108 %
November	2,117	2,984	41
December	2,446	3,175	30
1887.			
January	2,138	3,111	46
February	1,578	2,180	38
March	1,190	1,936	63
April	1,035	1,639	58
May	971	1,031	7
June	703	1,016	45
July	701	1,093	56
August	1,462	1,845	26
September	1,846	2,909	63
October	2,633	3,958	50
November	2,984	5,427	81
December	3,175	6,372	101
Totals	26,257	41,309	56%

It will be noticed that, whereas the total business shows the satisfactory increase of 41,309 units as compared with 26,257 in the former period of fifteen months, the most recent improvement is still more marked; the units consumed in December, 1887, being 6,372, as against 3,175 in December, 1886, and the consumption in the quarter ended December 31st, 1887, 15,757 units, as compared with 8,795 units in the corresponding quarter of 1886. In view of these figures, the directors feel confident that, with the proposed additional machinery at their command, they will be able, during the current year, to considerably augment their gross receipts; and as the expenses will not grow in anything like the same proportion, a substantial improvement in the profits will, in their opinion, result.

The following is a list of the present installations of the Company:—London, Brighton, and South Coast Railway Station, the Grand, Bedford, Clarence, Quadrant, and Gloucester Hotels; The Orleans and Union Clubs, the Oxford Music Hall, the Chapel Royal, the Sussex Daily News Office, the Swiss Mountain Railway; the private houses of Sir Albert Sassoon, Reuben Sasoon, Esq., Arthur Sassoon, Esq., Panmure Gordon, Esq., Frederick Shoolbred, Esq., James Willing, Esq., G. Attree, Esq., Sen., G. F. Attree, Esq., Jun., F. W. Jowers, Esq., M.D., G. R. Miller, Esq., Charles Catt, Esq., Charles Lamb, Esq., Edward Scott, Esq., Colonel Tamplin, Frederick

Druce, Esq., and W. J. Smith, Esq.; the offices of James Willing, Esq., G. Attree, Esq., Messrs. Tamplin and Son, Messrs. J. L. Denman and Co.; the boarding houses of Mr. A. F. Lamette, the Dudley, and Dudley Mansion; J. L. Gore, Connaught House; Mr. Buchel, Belvedere Mansion; and Mr. Worth, Haslemere House; and the following shops:—Messrs. Wells and Co., Messrs. Louis Wolff and Co., Messrs. Henocksberg and Pool, Messrs. Williams and Co., Messrs. Pope and Son, Messrs. Cheeseman and Co., the Waterproof Stores, Photographic Company (Limited), Messrs. Allen and Thompson, Messrs. Lewis and Son, the Drug Stores, Mr. Lediard, Mr. Soper, Mr. Ullman, Mr. Lawson, Mr. Green, Mr. Lawrence, Mr. Kemp, Mr. Baker, Mr. Stevens, and Mr. Munden.

Mr. Arthur Wright, who, while in the employ of Messrs. Hammond and Co., started the works at Brighton in conjunction with Mr. Robert Hammond, and who has brought them to their present state of efficiency, has continued to act as managing director; and the thanks of the shareholders are due to him for the highly satisfactory manner in which he has conducted the business of the Company during the period under review. He reports that the engines and dynamos have continued to give satisfaction, and are at the present time in thoroughly good working order. There has not been one single breakdown of the machinery during the fifteen months. The whole installation is in a much higher state of efficiency than it was at the date of the last report.

PROVISIONAL PATENTS, 1888.

FEBRUARY 3.

1649. **The sectional vulcanised fibre electrical incandescent lamp cap and crown.** William Davis and Thomas James Turner, New Court, Throgmorton-street, London, E.C.

FEBRUARY 4.

1681. **Improvements in electrical appliances and apparatus connected therewith.** Walter Thomas Goolden and Llewelyn Birchall Atkinson, 23, Andalus-road, Clapham, S.W.

FEBRUARY 6.

1733. **Improvements in the method of and apparatus for depolarising the negative elements of galvanic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

FEBRUARY 7.

1798. **Improvements in telephonic transmitters.** Thomas Laurie, 115, St. Vincent-street, Glasgow.

1818. **Tanning by electricity; in a tanning pit or trough, the combination of motionless hides, skins, &c., with a circulating tanning liquor traversed by an electric stream.** George Webber Rhodes, Friern Park, North Finchley, Middlesex.

1835. **Improvements in the construction of apparatus for communicating currents of electricity to persons on the introduction of specified coins or checks.** James Tarbotton Armstrong and Auguste Serraillier, 8, Quality-court, London, W.C.

1843. **Improvements in rheostats and rheotomes.** John Clayton Mewburn, 169, Fleet-street, London. (La Société Anonyme pour la Transmission de la Force par l'Electricité, France.)

FEBRUARY 8.

1869. **Improvements in the manufacture of carbons for electric purposes.** Augustus Tack, 15, Bennett-park, Blackheath, London, S.W.

1875. **Improvements in dynamo-electric machines and in electro-motors.** George Hookham, 7 and 8, New Bartholomew-street, Birmingham, and Robert Holden Housman, Perry Hall, Bromsgrove, Worcestershire.

1876. **Improvements in the armatures of dynamo-electric machines and of electro-motors.** George Hookham, 7 and 8, New Bartholomew-street, Birmingham.

1891. **A flexible battery cell and method of arranging the elements therefor.** Mark Bailey and John Warner, 21, Finsbury-pavement.

1919. **An improvement in arc electric lamps.** Arthur James Howes, 28, Southampton-buildings, Chancery-lane, London, W.C.

1926. **A mechanical chair or seat for the delivery of a current of electricity upon the insertion of a coin.** Henry Charles Braun and Arthur Ford Lloyd, 28, Clipstone-street, London, W.

FEBRUARY 9.

1932. **Improved forms of electrical contacts for switches and similar fittings.** F. H. Royce, Blake-street, Hulme, Manchester.

1964. **Improvements in electrical switches suitable for incandescent lamps.** Frederick Thomas Schmidt, Sunbridge-chambers, Bradford, Yorkshire.

1968. **An improved secondary battery or accumulator for the storage of electricity.** Walter Tilley, 11, Lewes-road, Brighton.

1981. **A new or improved electro-motor.** Thomas Parker, of the firm of Elwell-Parker (Limited), 70, Market-street, Manchester.

1991. **The manufacture of nickel electro-types.** Thomas Leman Matthews Hare and Louis Boudreaux, 31, Essex-street, Strand, London.

COMPLETE SPECIFICATIONS ACCEPTED.

MARCH 2, 1887.

3225. **Improvements in and relating to the generation and distribution of electric energy and machines or appliances therefor.** Robert Dick and Rankin Kennedy, 96, Buchanan-street, Glasgow.

MARCH 17, 1887.

4032. **Improved holder for brushes of electro-motors and dynamo-machines.** Moritz Immisch, 52, Chancery lane, London.

MARCH 22, 1887.

4322. **Improvements in dynamo-electric machines.** John Hopkinson and Edward Hopkinson, 47, Lincoln's Inn-fields, London, W.C.

MAR H 25, 1887.

4472. **Improvements in electro-deposition of cobalt.** Silvanus Phillips Thompson, 423, High Holborn, Middlesex.

APRIL 4, 1887.

4978. **An improved holder and switch for electric lamps.** Frederick Thomas Schmidt, Sunbridge Chambers, Bradford, Yorkshire.

4980. **Improvements in apparatus for making and breaking electrical circuits in connection with call or alarm boxes.** Frederick Thomas Schmidt, Sunbridge Chambers, Bradford, Yorkshire.

5009. **New and improved methods of charging and re-charging, cleansing, changing and varying the chemicals and liquids used in secondary batteries (or accumulators).** James Tarbotton Armstrong, 8, Quality-court, London, W.C.

APRIL 5, 1887.

5092. **Improvements relating to switches for electrical purposes.** Bela Egger, 45, Southampton-buildings, London.

APRIL 9, 1887.

5228. **Improvements in holders for incandescent electric lamps.** William Henry Bayley, 2, Bernard-street, Walsall.

APRIL 19, 1887.

5707. **Improvements in automatic cut-outs for electric arc lamps worked in series.** Edward Frederick Hermann Heinrich Lauckert and Henry Walter Kingston, 28, Southampton-buildings, Chancery-lane, London, W.C.

APRIL 25, 1887.

5972. **A new and improved method of attaching telegraphic, telephonic or other insulators to bolts, spikes, and the like.** Alexander Johnston, The Imperial Hotel, Dundee.

MAY 12, 1887.

6972. **Apparatus for obtaining derived currents of variable intensity from a main electric current.** John Clayton Mewburn, 169, Fleet-street, London. (La Société Anonyme pour la Transmission de la Force par l'Electricité, France.)

SPECIFICATIONS PUBLISHED.

1887.

2130. **Electrical inductors, &c.** F. Jehl. 8d.
2134. **Miners' safety lamps.** A. Schanschieff. 8d.
3560. **Electric lamps.** E. C. Warburton. 8d.
3611. **Laying electrical conductors underground.** G. Forbes. 8d.
3782. **Electric telegraphs.** E. Edwards. (Kunhardt.) 8d.
3783. **Morse keys, &c.** E. Edwards. (Cassalette and Kunhardt.) 8d.
3785. **Junction and testing boxes for electrical conductors** E. W. Beckingsale. 6d.
3917. **Telephones.** C. Wittenberg. 8d.
9725. **Dynamo-electric machines.** W. P. Thompson. (Westinghouse.) 8d.
14,260. **Preventing induction in telephonic circuits.** S. C. Drew. 6d.
15,588. **Dynamo electric machines.** J. Y. Johnson. (Rechniewski.) 6d.
16,558. **Measuring, &c., electric currents.** A. Wright. 6d.

1877.

1387. **Electric apparatus for actuating railway brakes.** F. F. A. Achard. 8d.

1847.

11,783. **Lighting by electricity.** W. E. Staite. 1s. 3d.

1878.

2477. **Electric lighting.** R. Werdermann. 11d.

1875.

2410. **Electric submerged lamp.** F. M. A. Chauvin and others. 8d.

NOTICE.

The Notices hitherto sent by the Office to Applicants for Patents, reminding them of the date for filing a Complete Specification, will not in future be issued.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	98 to 100
12 Feb.	1/2	Anglo-American Brush E.L.	4	$3\frac{3}{4}$
12 Feb.	2/0	— fully paid	5	$4\frac{3}{8}$
28 Oct.	7/6	Anglo-American	100	$40\frac{1}{4}$x
28 Oct.	15/0	— Pref.	100	$66\frac{1}{2}$
12 Feb., 85...	5/0	— Def......................	100	$14\frac{3}{8}$
29 Dec.........	3/0	Brazilian Submarine.........	10	$11\frac{7}{8}$
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
28 July	8/0	Cuba	10	12
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	$4\frac{1}{4}$
18 Oct.	5/0	— 10% Pref.	10	$9\frac{1}{2}$
14 Oct.	2/0	Direct United States	20	$8\frac{7}{8}$
12 Jan.	2/6	Eastern	10	$11\frac{1}{4}$
12 Jan.	3/0	— 6% Pref.	10	$14\frac{3}{4}$
1 Feb	5%	— 5%, 1899	100	109
28 Oct.	4%	— 4% Deb. Stock	100	105
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	$12\frac{3}{8}$
1 Feb.	6%	— 6% Deb., 1891	100	109
3 Jan.	5%	— 5% Deb., 1900	100	105x
2 Nov.	5%	— — 1890	100	102
3 Jan.	5%	Eastern & S. African, 1900	100	$104\frac{1}{2}$
12 Jan.	5/9	German Union	10	$9\frac{3}{4}$
27 Jan.	1/6	Globe Telegraph Trust......	10	$5\frac{3}{4}$
27 Jan.	3/0	— 6% Pref.	10	$13\frac{1}{2}$
3 Jan.	5/0	Great Northern...............	10	14x

Dividend.		Name.	Paid.	Price. Wednesday.
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105
28 July	10/0	India Rubber, G. P. & Tel.	10	18
28 Oct.	12/6	Indo-European	25	39
16 Nov.	2/6	London Platino-Brazilian...	10	4 13-16
16 March ...	5%	Maxim Western..............	1	$\frac{1}{4}$
15 May	5%	Oriental Telephone	11	$\frac{3}{8}$
14 Oct.	4/0	Reuter's	8	$8\frac{1}{2}$
......	...	Swan United	$3\frac{1}{2}$	2
28 July	12%	Submarine	100	135
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	$39\frac{1}{2}$
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	13 5-16
......	...	West African	10	5
1 Sept.	5%	— 5% Debs.	100	93
29 Dec.........	6/0	West Coast of America ...	10	5 7-16
31 Dec.	8%	— 8% Debs.	100	115
14 Oct.	3/9	Western and Brazilian......	15	9
14 Oct.	3/9	— Preferred	$5\frac{1}{2}$	$6\frac{1}{4}$
......	...	— Deferred..................	$2\frac{1}{2}$	3 1-16
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	107
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	9 15-16
13 May, '80...	...	— 6% 2nd Pref.	10	$6\frac{1}{2}$
2 Nov.	7%	West Union of U.S.	\$1,000	125
1 Sept.	6%	— 6% Sterling	100	$102\frac{3}{4}$

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Jan. ...	£39,878	+ £547
Brazilian Submarine	W. Feb. 3 ...	£2,730	...	Great Northern	M. of Jan. ...	21,400	+ 1,000
Cuba Submarine	M. of Jan. ...	3,300	+ £82	Submarine	None	Published.	
Direct Spanish.....................	M. of Jan. ...	1,943	+ 39	West Coast of America	M. of Jan. ...	4,800	...
— United States	None	Published.	...	Western and Brazilian	W. Feb. 3	1,562	...
Eastern..............................	M. of Jan. ...	56,164	+ 2,729	West India and Panama	F. Jan. 31......	3,200	+ 378

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Electric Traction Company (Limited).—Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, E.C., with a capital of £30,000 in 3,000 shares of £10 each. Object: to carry on the business of manufacturers and contractors for the supply of electrical power of all kinds, &c. The first subscribers are—

	Shares.
Viscount Bury, Quidenham, Norfolk	1
Lord Egerton of Tatton, Knutsford..............................	1
R. Macpherson, Willesden	1
Sir R. Abercromby, Bart., 17, Charles-street, W............	1
F. W. J. Hubel, Malden-crescent, N.W.	1
J. Paxman, Colchester	1
A. A. C. Keppel, Eccles Hall, Norfolk	1

The first directors shall be appointed by the subscribers to the memorandum of association. The regulations contained in the table marked A in the first schedule of the Companies' Act, 1862, shall apply to this company with slight modifications.

Eclipse Electric Lighting Syndicate (Limited).—Registered by Ernest Wood, 4, Broad Street-buildings, E.C., with a capital of £20,000 divided into 20,000 shares of £1 each. Object: to carry into effect an agreement, dated February 4, 1888, and made between John Garford, of the one part, and Willoughby Hamilton Tower, as trustee on behalf of the company, of the other part, to purchase and acquire the inventor's letters patent, &c.; to carry on business as manufacturers an electric light company in all its branches. The first subscribers are—

	Shares.
J. Garford, 3, Vernon-chambers, W.C.	1
J. Robinson, 60, Gresham-street, E.C.	1
W. H. Powes, Silverdale, Kent	1
W. C. Loe, Isleworth...	1
H. Martyn, 68, Leadenhall-street, E.C.........................	1
H. E. Robinson, 11, Poultry, E.C.	1

The business of the company shall be managed by the board of directors, whose number shall not exceed nine nor be less than three. The first shall be Sir Charles Clifford, Bart., John Garford, Esq., and Valentine Robinson. The qualification of a director shall be the holding in his own right 200 shares of £1 each, and by way of remuneration they shall be paid for their services the sum of £150 per annum. The regulations of Table A in the first schedule to the Companies' Act 1862, do not apply to this company.

India Rubber, Gutta Percha, and Telegraph Works Company.—The report of this Company for the year ending December 31 states that the net profit amounted to £13,174, which, with the balance brought forward, and deducting £20,800 paid on an interim dividend, leaves a disposable balance of £30,330. The directors recommend a dividend of 10s. per share, tax free, making, with the interim dividend, a total payment for the year of 10 per cent., and leaving £9,530 to be carried forward. The Company, it is stated, did an increased general business in the year; but competition and cost of raw materials also increased, and kept down the rate of profit on manufactured goods.

Telegraph Construction and Maintenance Company.—Subject to the audit of the accounts, the directors of the Telegraph Construction and Maintenance Company, Limited, propose paying a dividend of 15 per cent. (£1 16s. per share), in addition to the 5 per cent. already paid, making 20 per cent. for the year 1887.

Western Brazilian Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the past week, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Company, were £2,559.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the past week amounted to £3,856.

NOTES.

Telegraphic Money Orders.—Mr. Heaton's proposal for telegraphic money orders will, it is said, shortly be put to a practical test.

A New Accumulator.—It is stated that the firm of Rothschild has purchased the patent for a new accumulator devised by M. Laurent Cély.

The Electric Light in Sweden.—The town of Falun is shortly to be lighted with 50 arc lamps, of 1,200 c.-p., and 300 incandescence lamps.

Train Signalling.—A new electrical system of communication between guards and drivers of trains is about to be tried by the Metropolitan District Railway Company.

The Electric Telegraph in Spain.—The Administration of the Spanish Telegraphs will sell by auction on the 15th prox. the right to establish and work a telegraphic system in the town of Cordova.

Messrs. Woodhouse and Rawson.—The factory for the manufacture of lamps and electrical apparatus established by this firm at Saint Nicolas d'Aliermont, Seine Inférieure, has been in operation since the 1st inst.

The Electric Light in Bulgaria.—The Municipal Council of Sofia is considering the question of lighting this city by electricity. A prize of 5,000fr. will be awarded to the author of the best scheme of illumination, whether by gas or by electricity.

Laxton's Price Book.—This well-known price book has reached its seventy-first edition. It contains several pages devoted to prices of apparatus connected with electric lighting, which will be useful to architects and others who have to estimate for such work.

Kensington.—The sub-committee of the Kensington Vestry have advised the Works Committee of that body to postpone a decision on the order sought by the Kensington Court Electric Light Company, in order to give rival companies time to present their plans.

The E.P.S. Accumulator.—The Electrical Power Storage Company have received information from Mr. W. H. Preece, F.R.S., that some of their E.P.S. cells for electric lighting have been in use at his house for two years without failure or expense, and look as good as new.

Postal Telegraphy.—The First Lord of the Treasury Has written to Mr. Henniker Heaton, M.P., stating that the question of granting inquiry into the postal and telegraphic communication between England and all other parts of the Empire is under the consideration of the Cabinet.

Gas and Electricity in America.—According to the *Gaslight Journal*, there are 56 companies engaged in supplying electric light, and four were incorporated during the year. Four gas companies during the year were authorised to supply electric light, and three more have petitioned for similar permission.

Opposition to Telephone Bill.—At a meeting of the St. George's (Hanover-square) Vestry, last week, it was agreed to oppose the Bill which the united Telephone Company propose to introduce into Parliament. The Commissioners of Sewers also signed a petition against this Bill at the meeting on Tuesday last.

The Electric Light in Brussels.—The Thomson-Houston Company have written to a foreign contemporary to point out that the incandescence lamps installed at the Molière theatre are not those of Edison, as was stated; but that the incandescence as well as the arc lamps throughout the theatre are those of the Thomson-Houston type.

The Electric Light at Brunswick.—A company has just been established at Brunswick for lighting a portion of the town by electricity; it is intended to include the ducal palace and the Court theatre in the radius of distribution. Several proposals on the part of foreign con tractors are also under the consideration of the Communal Council.

The Abyssinian Expedition.—According to a telegram from Italy, relative to the Italian expedition at Massowah, the electric light machinery and apparatus sent out with the expedition has been taken to Saati, in order that the work of constructing the posts there may be carried on by night when the heat renders day labour unadvisable.

Faversham.—The residence of W. J. Rigden, Esq., M.F.H., has been fitted throughout with over 100 incandescent lamps, the system employed being that of Messrs. Laing, Wharton, and Down, and the fittings those of the artistic hammered coppered fittings usually connected with their name. The light has also been put into the brewery, offices, and private stables.

Wood Used in Telephony.—The S.S. "Gothenburg City" arrived at Antwerp on the 8th inst., from Newport News, Virginia, with 1,270 tons of walnut logs consigned to the Bell Telephone Manufacturing Company. This cargo of walnut, which is one of the largest ever brought to Europe, comprising no less than 1,828 logs, will be used entirely in the manufacture of telephone apparatus.

Primary Batteries.—A good word for a primary battery, as a means for electric illumination, has at length been spoken. During the Christmas festivals, the church of St. Clement at Prague was lit up by means of a primary battery; and the experiment is considered to be so satisfactory that it is intended to establish a permanent installation on the same basis. No details are given as to the precise nature of the battery.

Provisional Orders.—Mr. Barclay, in the House of Commons on Thursday, asked in how many cases the powers obtained by Provisional orders under the Electric Lighting Act of 1882 have been actually exercised; why so little progress had been made with electric lighting under the Act of 1882; and whether the Government intends to amend the Act, with the view of encouraging the development of electric lighting.

The Electric Light at Vienna.—The *Allgemeine Elektricitaets* of Berlin has established a branch establishment at Vienna, where it is negotiating with the Imperial Gas Association for the purchase of its premises in the Schenkenstrasse and of the installation at the opera. The exhibition which will shortly take place on the Prater will be illuminated by electricity; the motive power for this installation is estimated at 600 h.-p.

The Electric Light in Rome.—The gas company of Rome is energetically developing the central station for distributing the electric light which it has established in that city by means of the Zipernowski transformers. A capital of more than two millions of francs has already been expended in this enterprise. This, however, is considerably below the expenditure of three and a half millions made at Vienna by the Continental and Imperial Gas Company.

dynamo machine by a four horse-power gas engine. The installation was carried out by the Maxim-Weston Company, under the direction of Mr. Thomas Floyd, of Victoria Mansions. The premises are capitally illuminated.

Intercolonial Postal Conference.—Arrangements are made for holding an Intercolonial Postal and Telegraphic Conference in Sydney, as it is felt that the Colonies might be in greater harmony upon these subjects than they are. In the matter of telegraphy alone there is room for much improvement, especially as between New Zealand and the Australian group of Colonies in the matter of press telegrams. As it is, these are few and far between, and the result is that New Zealand loses that publicity in respect to its social, industrial, and political concerns which the press of Australia might give it, by reason of its more frequent intercommunication with Europe, if the New Zealand telegraphic rates were not so high. The subjects for discussion are the Ocean Mail Service question in its various phases, the New Zealand Cable and Pacific Mail Service questions, as well as any others relating to postal or telegraphic matters which any delegate may desire to bring forward. The Victorian Ministry arranged at a Cabinet meeting on January 5 to decline specific action respecting the subsidy to the Pacific cable project until the proposed Postal Conference in Sydney has sat and completed its business.

Effects of Current on Wine.—From the *Journal* of the Chemical Society we gather that F. Mengarini has continued the investigations of Blaserna and Carpine, who have shown that wine is artificially matured by the action of a current. In Mengarini's paper some further experiments on this subject are described, in which a current of 3·99 amperes per hour was passed for various periods of time through a sample of Italian wine; analyses were made of the wine without and with passage of the current and the results compared. The platinum electrodes were found to be covered with albuminous substances, blackened by oxidation; there was also a considerable deposit of these substances. The proportion of alcohol was diminished partly by the slight concomitant formation of acetic acid, partly also by evaporation, and partly also by its destruction by a more profound oxidation. There was also imparted to the wine a perfume similar to that acquired by maturing; this increased by prolongation of the current. The passage of the current also assists its future preservation. The colouring matters are affected, but the author would not for the present draw any conclusions from his experiments. If by passage of an electric current the wine could be sterilised, so as to effect the complete removal of *Bacterium aceti*, this process would be of considerable technical importance.

Central Electrical Laboratory.—The inauguration of this establishment, created by the International Society of Electricians, and provisionally installed at *place* St. Charles, Grenelle, recently took place under the presidency of M. Mascart. Amongst those present were M. Coulon, the director of posts and telegraphs, and many deputies, municipal councillors, engineers, electricians, and manufacturers. The interest arising from the sum of 300,000fr., constituting the balance left from the Electrical Exhibition of 1881, has been appropriated to the support of the laboratory in question. In the first room are placed the prime motors—a Weyher and Richemond locomobile of 20 h.-p., and a Lenoir gas engine of 12 h.-p.—working the dynamo machines of Edison, Gramme, and Sautter-Lemonnier. The illuminating apparatus comprises 5 Cance lamps, 2 Jablochkoff bougies, and 60 Edison incandescence lamps. In a second room are neatly arranged the various photometric apparatus; in proximity to which is a large chemical laboratory for the study of accumulators and primary batteries. Beyond is the room for obtaining measurements in absolute units, and, lastly, a room in which measurements are made in practical units for industrial purposes. The main subjects for investigation will be the efficiency of machines, the mechanical and electrical properties of cables and other conductors, and the calibration of instruments. Students will also be initiated in electrical measurements and other practical work.

A New Telephone Company.—According to a Chicago paper, a new telephone company in Chicago, to compete with the Bell monopoly, will soon be an assured fact, provided the City Council looks favourably upon the scheme. The undertaking in question, the Cushman Company, is under the presidency of City Treasurer Piantz, and purposes to furnish a telephone service at 80 dollars per annum. One of the officers of the proposed company, in reply to questions, said:—"Dr. Cushman, who invented our instrument, made the first telephone, away back in 1851. He was then making a telegraph line from Racine to Beloit, Wis., and discovered the telephone principle by accident. In making a lightning arrester he placed the box, with the wire connections, in a swamp, and 16 miles further on put up another. One day he chanced to get his ear close to the box, and was astonished to hear the croaking of frogs in the swamp, sixteen miles away. He then began experiments over the wire, and the result was what he called a 'talking-box.' The device was used for several years by different parties, and that is the reason we claim that the Bell Company has no right to their patent. Bell's invention of 1875 was the talking-machine of 1851. You talked into and received from the same box. It was the transmitter—which was not invented by either Bell or Cushman—that made the telephone. We are the only fighting competitors of the Bell Company, and we went down to Indiana and went at them boldly."

Austria.—The motive power required for the Jubilee Exhibition at Vienna, says *Industries*, was at first estimated at 450 h.-p., afterwards at 600 h.-p., and now it is reckoned that it will reach 1,000 h.-p. The lighting of the fountains, which it is proposed to effect in the same manner as at the exhibitions in London and Manchester, has not been included in this estimate. The number of applications from persons wishing to exhibit is considerably higher than was anticipated. The Town Council of Stockerau are at present divided in opinion as to the advisability of using gas or the electric light. Sixteen councillors are in favour of the adoption of gas, and twelve advocate the employment of electricity. It has been decided to adopt gas for lighting purposes; but the necessary money for the carrying out of the project has not been granted, since the consent of more than sixteen councillors must be obtained before the money can be spent. The partisans of electricity still hope to prevail on the majority, so that the electric light may be eventually installed. In some spinning mills in the Erzgebirge the electric light has been installed. On winter mornings artificial light has to be used till 10 a.m., and in the afternoon from about 3:30 p.m. The glow lamp installation in the Court Theatre is progressing but slowly, and is not expected to be finished before the autumn. The Houses of Parliament are also to receive an electric light installa-

tion; the lighting will, however, be restricted to the legislative chambers and lobbies, the private rooms remaining lit by gas as heretofore.

Brussels Exhibition.—With reference to the subject of the note under this heading in our last issue, the following letter has been addressed by the Executive Committee to Count d'Oultremont, the Commissary-General of the Belgian section, in reply to the communication from "the Members of Committee 47":—"Monsieur the Commissary-General,—Although the question brought to your notice by the Committee 47 of the Grand Concours is by no means within the province of that Committee, since it relates to an essentially private enterprise, we are anxious nevertheless to afford you every explanation and satisfaction in replying to the demand you addressed to us. The rumour, according to which the work of electric lighting is placed entirely in the hands of foreign firms, is absolutely erroneous. The national electrical industry will doubtless take a great part in the organisation of this service. This would be a natural consequence of the arrangements established by us up to the present date. Though it may be evidently desirable—as is observed by Committe 47—that all Belgian electricians should take part in the undertaking, it is also evident that the realisation of this wish must depend, in the first place, on the conditions offered by these electricians to the *Société du Grand Concours.* The statement relative to the letting of space in the Belgian electrical section bears also the impress of error. We know, in fact, that other firms besides the 'Société Industrielle' have applied for space in this section; and we know, moreover, that these firms have decided to occupy a vast area by reason of the important share conceded to them in our undertaking of the lighting. Please to accept, &c., (Signed) LEON SOMZEE."

Electric Lighting in France.—According to the *Bulletin International de l'Electricité,* the central distributing station installed at Nancy by the Edison Company is a complete success, the working of the Zipernowsky transformers being very satisfactory. The importance of this fact would appear to be recognised by the gas interest; for a number of gentlemen connected with it have requested permission to visit the new works, which they did on the 16th inst., under the conduct of M. Chatard, the manager of the Edison Company.—At Reims, on the other hand, the projects of electric lighting appear to have "passed into the domain of silence." Not only has the project of establishing a central station been, for the present at least, abandoned; but it is stated that all attempts to work the installation in the cellars of the Pommery premises have been relinquished. This can be due only to serious defects in this installation; and the fact illustrates the importance of entrusting such installations to competent hands.—The electric light is about to be introduced in the theatre at Béziers. Strange though it may sound to our ears, it is the gas company of that town which—following the lead of their *confrères* at Lyons—has undertaken to carry the installation into effect. We may well exclaim that "they manage these things better in France!"—At Montpellier the application of the gas company for a concession of the electric lighting has been refused, by reason of their stipulation that the rights at present vested in them should be prolonged for ten years. These rights being already secured to them for thirty years, the Municipal Council of Montpellier decided to accept the proposals of M. Popp rather than authorise an extension of the rights in question.

The Electric Light in Brussels.—The following details in relation to the electric lighting of the vast establishment of Hirsche at Brussels are given by the *Bulletin International.* The lighting comprises 300 incandescence lamps and 36 arc lamps. The latter are distributed at the entrance and on the ground floor, whilst the upper floors and offices, the underground workshops and the passages are illuminated by the former; the use of gas being entirely discontinued. The motive power consists of a steam engine of 80 h.-p. effective, on the Walschaert's system, with multitubular boiler. This machine actuates two compound dynamos of the Boukaert type, each giving 110 volts and 175 amperes. The arc lamps are of the Piette and Krizic form, 26 of them being of 600 c.-p., 8 of 1,000 c.-p., and 2 of 1,400 c.-p.; these last being placed at the entrance, where they are very conspicuous. The incandescence lamps, of the Swan type, are of 16 c.-p. The lamps are alternately connected to the two dynamos; so that, in case of accident to one of them, there is but a partial extinction of the light. From the economical, as well as from other points of view, the lighting is a complete success. The cost of the gas annually consumed in the Hirsche establishment was 28,000fr.; whereas, from its owner's calculation, the cost of the electric lighting will not be above 13,000fr., in which sum is included the amortisation at the rate of 12½ per cent. of the capital expended in the installation. There will consequently be a saving of 15,000fr. per annum, which is the more remarkable from the fact that gas is comparatively very cheap in Brussels—viz., 15c. the cubic metre. The installation has been carried out by the firm of Bouckaert and Co., of Brussels.

Exeter.—At a public meeting held in the Victoria Hall, Exeter, on Tuesday, it was proposed and carried unanimously "that in view of the great satisfaction given in the lighting of Exeter streets by electricity, this meeting is of opinion that it would be to the interest of the city and add to its attractiveness and prosperity if the public streets were permanently lighted by the system of arc lighting now in use." Following on this proposition was another, which was also carried unanimously, "that it is the desire of this meeting that a local company should at once be formed for the purpose of supplying Exeter with the Thomson-Houston system of electric lighting for public and private use." These propositions were carried, after Mr. Wharton, of the firm of Laing, Wharton, and Down, had explained to the audience, which numbered some 2,000 persons, the present position of the electric light, sketching its method of production and its history, and suggesting that the best possible way for any town to obtain the electric light was to form a local company. He estimated the cost of arc lamps at about £20 each per annum, and the incandescent for domestic purposes at ¼d. per hour, and stated that the electricity could be measured by meters as in the case of gas. A number of questions were asked of Mr. Wharton by various gentlemen in the room, which, as will be seen from the unanimous feeling of the meeting, were satisfactorily answered. Exeter is in a position to obtain the light upon more economical conditions than some other towns, as there is a large supply of water power now running to waste, and no doubt when a company is formed this will be utilised. As we have said before, we think that this is a right direction in which to work—namely, the formation of local companies quite capable of looking after their own interest and seeing that the work is properly and economically done.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 129.*)

Resistance Boxes.—It is neither necessary nor practicable in these articles to describe the peculiarities of the boxes of resistances as supplied by different makers; but it seems desirable that the general principles of the construction of one or two of the more common forms should be described. The way in which the resistances are fixed in the box and connected to the contact plates outside the cover will be

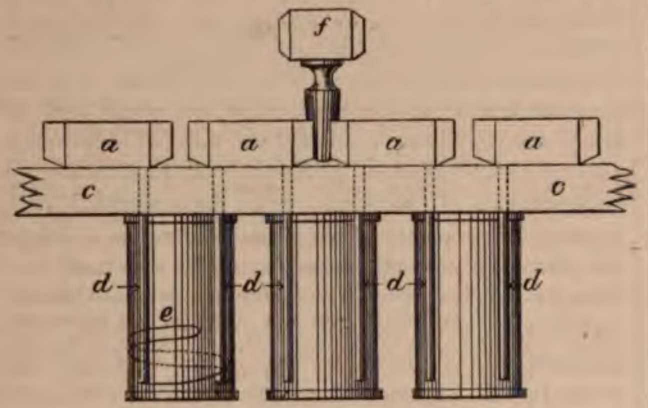


FIG. 4.

readily understood by reference to Fig. 4. In this figure *b b b* represent three bobbins which may be taken as part of a series. The bobbins may be wood or vulcanite or other insulating material, or they may be made of metal, but in that case they should be split up one side to avoid induced currents in them when the current through the coil is made or broken. When the bobbins are metal they should be covered with thin rubber, or paper soaked in paraffin or spirit varnish, before the wire is wound on, so as to avoid any chance of contact between the wire and the bobbin. These bobbins are fixed to the cover, *c*, of the box, which should be of highly insulating material and is usually made of vulcanite. On the outside of the cover rows of brass or copper blocks, *a*, are fixed in some such manner as that indicated diagrammatically in Fig. 5. To the underside of each of these blocks two rods, *d*, *d*, are soldered, and they pass through the cover projecting to, or nearly to, the bottom of the bobbins. The wires forming the resis-

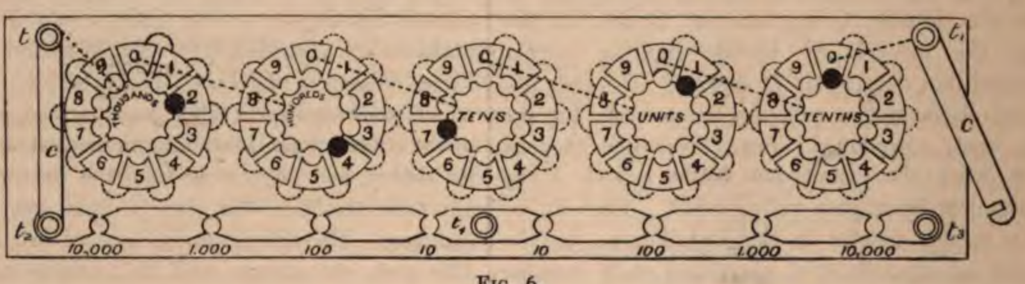


FIG. 6.

tances are wound on these bobbins, and generally, though not necessarily, each resistance has a separate bobbin. The wire should be doubled on itself, the ends soldered to the rods *d d*, and for convenience of adjustment the bend left on the outside as shown at *e*. The reason that the wire is doubled on itself is that a coil so wound has very little self-induction, and the more perfect the doubling, that is, the closer the two wires are kept to each other during the winding, the better. The rods *d* are introduced merely for convenience of manufacture; they should have very little resistance compared with the coil attached to them, or, if their resistance is a sensible fraction of that of the coil, the material of which they are made should be the same as that of the wire. It is important that both ends of each coil should have a separate rod connecting it to the brass block, as no part of the circuit of two successive coils should be common to both; each coil should terminate at the brass block, and the blocks must have such a section that the resistance of the whole circuit of blocks between the terminals of the box is a very small fraction, it should be less than a thousandth, of the lowest resistance in the box. The reason for this will become apparent when we come to the adjustment of the separate coils to their proper value. The wire of which the coils are composed should be such as not to change readily with time, and its resistance should change as little with change of temperature as possible. One of the best substances for the purpose is an

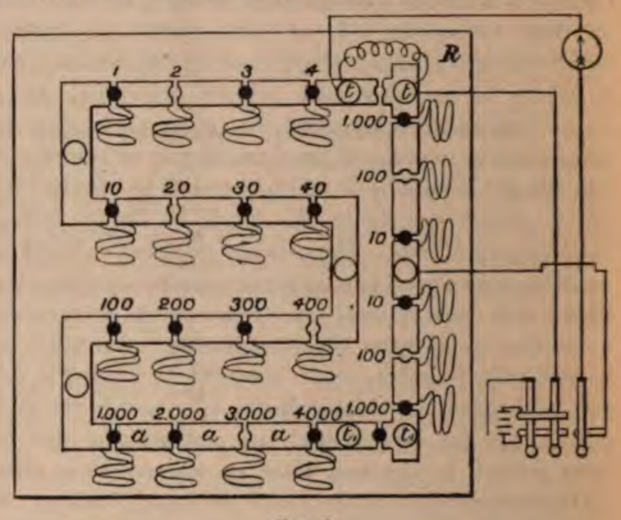


FIG. 5.

alloy of two parts by weight of silver to one of platinum, but this has the disadvantage of being expensive. German silver is commonly used, and in the form recently introduced under the name of platinoid it promises to do well for the purpose. It is, however, doubtful whether sufficient constancy with time and uniformity of temperature variation can be obtained with this material. The wire should be well covered with silk, and the finished bobbin should be stored for some hours at a temperature of about 120deg. C and then while hot immersed in melted paraffin, with which substance it should be thoroughly soaked. The paraffin should be pure and must be free from acid. The variation of the resistance of the wire with temperature introduces one of the greatest difficulties in the manufacture of perfectly reliable resistance boxes. The difficulty is mainly due to the fact that two different specimens of the same alloy seldom have the same temperature variation, and hence the coils of boxes which are adjusted to be correct at one temperature are seldom relatively correct at any other temperature. The temperature variation is found to depend not only on the composition of the metal, but also on its physical state as to hardness, annealing, and so forth. For this reason it is advisable to keep the wire heated for a day or two to a considerably higher temperature than that to which it is ever likely to be exposed in actual use, before it is standardised. The temperature variation of the different coils may be made equal by the introduction of such a length of wire having a high temperature variation, such as copper wire, into the different coils as is sufficient to raise their variations all to equality with that which varies most. The copper wire may either be introduced in series or in parallel with the other wire, but the series method is the simpler. It can be readily introduced near the bend, where the wire is doubled, after the coil is wound, or the

temperature variation of the wire may be determined to begin with, and the proper length of copper wire to bring the variation to a standard amount introduced in the interior of the coil. The coils are cut out of the circuit by means of brass plugs, *f*, as indicated in the figure, and one of the greatest defects of this arrangement lies in the fact that when only a few of the coils are required a large number of contact joints are included in the circuit, each one of which, and their sum, is assumed to have zero resistance. The vertical holes between the blocks are not easily cleaned, and hence the contacts between the plugs and blocks are apt to be imperfect, giving rise to error in the measurement. Perhaps the most satisfactory method of cleaning the holes is to wash them by means of a rod covered with cloth soaked in paraffin oil, and then dry them thoroughly with a dry cloth. They should never on any account be rubbed with glass or emery paper, as the fine glass or emery sinks into the surface of the metal and grinds the plug, at the same time preventing perfect contact. If washing will not do, the holes should be scraped with a round-pointed scraper. The same remarks apply to the cleaning of the plugs; they should be washed clean and, if that is not sufficient, they should be scraped clean but not papered.

A convenient arrangement for a set of resistances from one to ten thousand ohms, combined with two sets of ten, one hundred, and one thousand ohms, designed to form three sides of the Wheatstone's bridge arrangement, is shown in diagrammatic form in Fig. 5. The connections of the battery and galvanometer circuits are also indicated. The resistance to be measured is placed between the terminals $t\ t$, and the terminals $t_1\ t_1$ short circuited by a plug. The resistances of the sides *a* and *b* of the diagram, Fig. 3, are supposed equal in this case, and each of them 100 ohms, while the resistance R is supposed to have been balanced by 3,422 ohms, forming the side *d* of Fig. 3. The resistance of R would in such a case be 3,422 ohms since *a* and *b* are equal.

Another, and in some respects considerably better, form of resistance box is shown in plan in Fig. 6. In this form the brass blocks to which the ends of the resistances are attached are arranged in circles with a single circular block in the centre. The way in which the resistances are joined up is shown by dotted lines between the blocks. There are ten blocks in each circle and they serve to join nine equal resistances in series, the first and last block of each set being insulated from each other. The terminal *t* is joined inside the box by a thick rod of copper to the central block of the thousands circle, the block marked 0 of that circle is in a similar manner joined to the central block of the hundreds circle, and so on as indicated by the dotted lines in the figure, the block marked 0 of the tenths circle being joined to the terminal t_1. Two flat stout strips of copper, *c*, *c*, serve to join the terminals *t* to t_2, or t_1 to t_3, as may be desired. In front of the circles of blocks and joining t_2 and t_3, there is a straight row of blocks forming the terminals of two sets of resistances usually of the number of ohms marked in the figure. The box thus gives in a convenient form three of the sets of resistances required in the Wheatstone bridge arrangement. The terminals *t* and t_2 may be joined by the bar *c*, and the resistance to be measured introduced between t_1 and t_3, the bar being left out of contact with t_3, as shown in the figure, or t_1 and t_3 may be joined, and *t* insulated from t_2, and the resistance to be measured introduced at that end. In this arrangement one plug only is necessary for each circle. When the plug is placed in the hole between the block marked 0 and the central block there is no resistance in that circle when it is placed between the block marked 1 and the central block, the resistance introduced is $\frac{1}{10}$, 1, 10, 100, or 1000, according to the circle used, and similarly for the other numbers. Thus if the blackened circles are taken to represent the positions of the plugs the resistance between the terminals *t* and t_1 is 2471·0. The advantage of this arrangement is the small number of plugs required, and hence the correspondingly smaller chance of error due to resistance in their contacts. There are of course a considerably greater number of blocks required for the same resistances and a correspondingly greater number of resistances than in the form shown in Fig. 5. This causes greater expense in manufacture, arising chiefly from the greater number of separate resistances which have to be adjusted. The battery and galvanometer circuits should be joined up in a similar manner to that indicated in Fig. 5. As a general rule it is preferable to join the battery between the terminals t_2 and t_3, and the galvanometer between the terminal t_4 and *t* or t_1, according to the end of the box at which the resistance to be tested is inserted. The pair of resistances which it is best to use in the two front sets has of course to be determinined, for the particular case under consideration, by the rules given above.

(To be continued.)

A SIMPLE METHOD OF TREATING PROBLEMS CONNECTED WITH NETWORKS OF CONDUCTORS.*

BY W. E. SUMPNER, B.SC.

[The italic letters throughout the formulæ in this article have inadvertently been raised, and represent suffixes.]

Those who have taken the trouble to work out many problems connected with networks of conductors know very well how cumbrous are the expressions with which they have to deal. If determinants are not readily handled, a great deal of perseverance is required to arrive at the solution of any but the simplest problems, while even if they are constantly used the expressions obtained are still very complex—they seem mere mathematical abstractions, and appear to have no physical meaning. In all practical cases, moreover, the solution is of a simple kind, however complex the working may be; and as it is natural to suppose that whenever the solution of a problem is simple there must be some simple means of getting to it, it seems very reasonable to believe that in most cases there must exist some quicker and simpler method of solution than that usually employed.

Now, if in any given network of conductors we work out the relation connecting the current flowing in any one branch with the values of the electromotive forces acting in the various branches we always find the following result. If only one electromotive force is acting the current is proportional to the electromotive force. If there are two electromotive forces acting the current is the sum of two quantities, each of which is proportional to one electromotive force, and is independent of the other. In short, we always find

$$C_x = K_a\ E_a + K_b\ E_b + K_c\ E_c + . \ . \ .$$

Where C_x is the value of the current flowing in the branch of the network denoted by the letter *x*, where $E_a\ E_b\ E_c$ . . . are the electromotive forces acting in the branches denoted respectively by the letters *a*, *b*, *c*, . . . and where $K_a\ K_b\ K_c$ . . . are certain quantities depending only on the resistances of the different branches of the network. The above equation is only the mathematical way of making the statement that the current produced in any given branch by the combined agency of several electromotive forces is always the sum of the currents which would be produced in that branch by each electromotive force acting separately.

The truth of the equation is easily established when it is remembered that the current can only depend on the electromotive forces and resistances; that it is of the nature of an electromotive force divided by a resistance; that it cannot be made infinite by diminishing any one electromotive force to zero, and that it must be zero when no electromotive forces are acting.

If C_x depended partly on a quantity which was inversely proportional to one of the electromotive forces, it would become infinite when this was made very small. If it depended partly on a quantity which was proportional to the product of two or more electromotive forces, it could not be of the nature of an electromotive force divided by a resistance. C_x can, therefore, only be made up of terms, each of which is proportional to an electromotive force, and to this one only.

The quantities, K, in the above equation, depend only on the resistance of the branches. If we knew what were

* Paper read before the City and Guilds of London Institute Old Students' Association, Feb. 22, 1888.

their values we should know the solution of any given problem. Let us, for the present, assume that we know them; and let us denote by the symbol $R x g$ the ratio between an electromotive force, $E x$, placed in the branch, x of the network to the current, $C g$, in the branch g, produced by this electromotive force.

Then, if $E x$ is the only E.M.F. in the network, we have for the current in the branch g

$$C g = \frac{E x}{R x g};$$

and if there are many electromotive forces we have

$$C g = \frac{E x}{R x g} + \frac{F y}{R y g} + \frac{E z}{R z g} + \cdot\ \cdot\ \cdot\ \cdot\ \cdot$$

The currents and electromotive forces have direction, and, consequently, $R x y$ may be sometimes a positive quantity, and sometimes a negative one. If we choose at will a direction in each branch as the positive direction, and consider the current or electromotive force in that branch as positive when acting in the positive direction of the branch, then $R x y$ will be positive or negative, according as a positive E.M.F. in the branch x produces a positive or negative current in the branch y.

The quantities $R x y$ are generally very complex quantities. They are all of the nature of resistances, and may be called resistance ratios. Although the solution of any problem can easily be expressed in terms of them, it does not necessarily follow that is needful to calculate all or any of them in order to solve any given problem. Most practical problems have very simple solutions, while the resistance ratios are nearly always very complex quantities. It must therefore be possible in most cases to eliminate them from the solution without actually calculating them out. It consequently seems more important to find out relations between these quantities than to express them directly in terms of the resistances of the different branches of the network.

One of the most important properties of these ratios is that

$$\frac{R x y}{R x z} \text{ is independent of } x \quad . \quad . \quad . \quad . \quad (1)$$

where the resistance of the branch x is denoted by x. Suppose the only E.M.F. in the network is that in the branch x. The value of $C y$, the current produced in the branch y, will be directly proportional to the value of $C x$, the current in the branch x. It will be, moreover, independent of x because it will be always possible to find out the value of $C y$ without knowing what x is. Now in this case

$$C x = \frac{E x}{R x x} \quad \text{and} \quad C y = \frac{E x}{R x y} \quad C_2 = \frac{E x}{R x z}$$

From this it follows that $\frac{R x y}{R x x}$ and $\frac{R x y}{R x z}$ are independent of x.

Now, if we denote by $R x$ the resistance of the network between the extremities of the branch x (supposing the branch x removed) it is easy to see that the value of $C x$, the current in x produced by the electromotive force $E x$, is

$$\frac{E x}{x + R x},$$

but it is also $\frac{E x}{R x x}$ by our definition of $R x x$. We accordingly have

$$R x x = x + R x. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and $R x x$ may be called the resistance of the x circuit.

We must not assume that $R x y$ and $R y x$ are the same. The first is the ratio between an E.M.F. in the branch x to the current produced by it in the branch y; the second is the ratio between an E.M.F. in the branch y to the current produced by it in the branch x. It is easy to see, however, that $\frac{R y x}{R x x}$ is independent of x.

Suppose there are two electromotive forces, $E x$ $E y$, in the network, such that they tend to send currents in opposite directions through the branch x. We then have

$$C x = \frac{E x}{R x} - \frac{E y}{R y x}.$$

Suppose the values of $E x$ and $E y$ so adjusted current $C x$ is zero, then

$$\frac{R y x}{R x x} = \frac{E y}{E x}.$$

But if the current in the branch x is zero, we the resistance x to any extent without causing to flow through the branch x. As we have r either of the electromotive forces by this proc that the new value of the ratio $\frac{R y x}{R x x}$ must be eq old ratio, or

$$\frac{R y x}{R x x} \text{ and } \frac{R y x}{R z x} \text{ are independent of } x \quad . \quad .$$

We have in any network of conductors

$$C g = \frac{E g}{R g g} + \Sigma \frac{E x}{R x g},$$

where $\frac{E g}{R g g}$ is the current produced by the E.M the branch g, and where $\Sigma \frac{E x}{R x g}$ denotes the sum rents due to the electromotive forces outside the

This equation may be written

$$C g = \frac{E g}{R g g} + \frac{1}{R g g} \Sigma \frac{R g g}{R x g} E x = \frac{K + E g}{R g g} \quad . \quad .$$

where $$K = \Sigma \frac{R g g}{R x g} E x,$$

and is independent of g and $E g$ by (1). K is motive force which, when placed in the branch duce in that branch the same current as the ele forces outside the branch s produce. It is im notice that it is a constant for alterations in the of the branch and in the E.M.F. $E g$.

Now, suppose we alter both the value of s an such a way

$$E' g - E g = (g' - g) C g,$$

where the dashed letters refer to the new valu we have

$$C g = \frac{K + E g}{R g g} = \frac{E' g - E g}{g' - g}.$$

From this we obtain by addition

$$C g = \frac{K + E' g}{R g g + g' - g}.$$

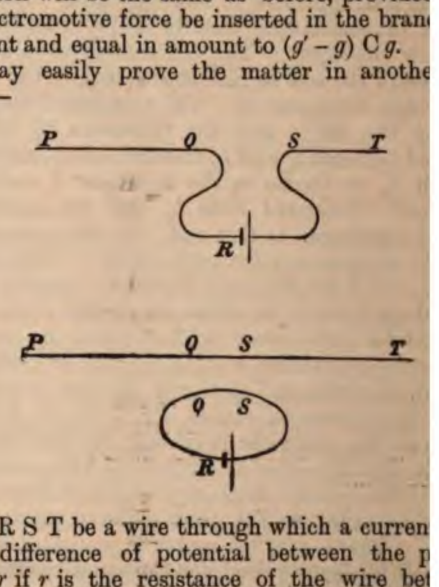
Now $R g g = g + R g$ by 2.

Hence $$R g g + g' - g = g + R g = R' g g$$

and $C g = \frac{K + E' g}{R' g g} = C' g$ by definition, or the ne $C g$ is the same as the old value.

5. This means that if $C g$ be the current in any any network of conductors, and if the resistance branch be changed to g' the currents in every the network will be the same as before, provided tional electromotive force be inserted in the bran the current and equal in amount to $(g' - g) C g$.

We may easily prove the matter in anothe follows :—



If P Q R S T be a wire through which a curren ing, the difference of potential between the p will be $C r$ if r is the resistance of the wire bet points Q S, and if there is no E.M.F. between Otherwise it will be $C r - E$ where E is the E.M.I

the two points. By choosing the position of the point S, so that $Cr - E$, the points Q and S will be at the same potential and may be joined by a wire of any resistance whatever without altering the current flowing either in the wire P R T, or that through any other wire in connection with it. If the resistance of the wire joining Q and S be zero, this will still be true. But in this case we practically have removed the resistance r and the E.M.F., E, from the network without changing the current in any branch by the process.

We may put this statement into mathematical language as follows:—

We have, if $E y$ is the only E.M.F. in the network,

$$C x = \frac{E y}{R y x} \text{ and } C z = \frac{E y}{R y z}.$$

Now alter the resistance of one of the branches z to z', and at the same time insert an E.M.F. in the branch z equal to $(z' - z)\, C z$.

The new value of $C x$ will be

$$\frac{E y}{R' y x} + \frac{(z' - z)\, C z}{R' z x} = \frac{E y}{R' y x} + \frac{z' - z}{R' z x}\,\frac{E y}{R y z},$$

where the dashed quantities are what the corresponding undashed quantities become when z' is put for z.

But by (5) the new value of $C x$ is equal to the old value:

$$\frac{E y}{R y x} = \frac{E y}{R' y x} + \frac{z' - z}{R' z x}\,\frac{E y}{R y z},$$

or, dividing out by $E y$, we have

$$\frac{1}{R y x} = \frac{1}{R' y x} + \frac{z' - z}{R' z x\, R y z} \quad . \quad . \quad . \quad (6)$$

Where $x\ y\ z$ are any three branches of the network (any two or all three of which may be the same),

From (6) we have by interchanging y and x

$$\frac{1}{R x y} - \frac{1}{R' x y} = \frac{z' - z}{R x z}\,\frac{1}{R' z y}$$

$$\frac{1}{R y x} - \frac{1}{R' y x} = \frac{z' - z}{R y z}\,\frac{1}{R' z x}.$$

By division we obtain

$$\frac{\dfrac{1}{R x y} - \dfrac{1}{R' x y}}{\dfrac{1}{R y x} - \dfrac{1}{R' y x}} = \frac{R y z}{R x z}\,\frac{R' z x}{R' z y} \quad . \quad . \quad . \quad (7)$$

Now, by (3) the right hand side of this equation is independent of both z and z'. The left hand side must, therefore, also be independent of z and z'.

This can only be if $\dfrac{R y x}{R x y}$ is independent of z, where z is the resistance of any branch of the network whatever. Now, since the ratios $R x y$ depend only on the resistances of the network branches, and since $R x y / R y x$ is independent of the resistance of any branch, the ratio must be a simple number, which, from symmetry, must be either $+1$ or -1. A reference to equation (7) shows that it must be the positive quantity.

For suppose $\dfrac{R x y}{R y x} = a = \dfrac{R y x}{R x y}$ by symmetry then from (7)—

$$\frac{a\left(\dfrac{1}{R y x} - \dfrac{1}{R' y x}\right)}{\left(\dfrac{1}{R y x} - \dfrac{1}{R' y x}\right)} = \frac{R y z}{R x z} \times \frac{R z x}{R z y} = \frac{R y z}{R z y} \cdot \frac{R z x}{R x z} = a^2,$$

$$\text{or } a = a^2, \qquad \text{or } a = +1.$$

We accordingly have the very important property due to Clerk Maxwell.

$$R x y = R y x \quad . \quad . \quad . \quad . \quad . \quad (8)$$

or the current in the branch y produced by an E.M.F. in the branch x is exactly equal to the current in the branch x produced by the same E.M.F. in the branch y.

We have in general

$$C g = \frac{E b}{R b g} + \Sigma \frac{E x}{R x g}.$$

Suppose the resistances of the branches of the network are so arranged that an E.M.F. $E b$ in the branch b produced no effect in the branch g. In this case the branches b and g are said to be conjugate. The current in g produced by the E.M.F. $E b$ is $E b / R b g$. But this is zero. Hence

$R b g$ is infinite when the branches b and g are conjugate . . . . (9)

But if an E.M.F. in b produces no effect in the branch g its alteration will not produce any effect. Now a given alteration of E.M.F. is always equivalent to a certain alteration of resistance by (5). Hence an alteration of the resistance b will produce no change in the current $C g$.

Now $$C g = \Sigma \frac{E x}{E x g}$$

and this is independent of b whatever the relative values of the electromotive forces, provided only that the branches b and g are conjugate. This can only be the case if

$R x g$ is independent of b when the branches b and g are conjugate . . . . (10)

This is another way of putting the general statement of Dr. Frölich, that if two branches are conjugate the current in one is unaltered by closing or unclosing the circuit of the other branch, however many electromotive forces may be acting in the rest of the network.

We may illustrate some of the above properties by applying them to a few simple problems.

To find the most sensitive galvanometer to use under given circumstances.

The current through the galvanometer at any moment will be by (4) equal to

$$\frac{K + E g}{R g + g}.$$

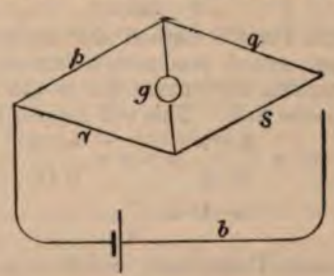
This will produce a deflection $\dfrac{S}{g + R g}\,(K + E g)$

where S is the deflection given by a unit current. If we alter the galvanometer we shall change S and g, but nothing besides, and the best galvanometer we can use is that which will make

$$\frac{S}{g + R g} \text{ a maximum.}$$

It will therefore depend on the resistance $R g$, which is external to the galvanometer. We may, in fact, compare a galvanometer to a battery. The latter has a given E.M.F. and internal resistance; the former has a given sensibility and internal resistance. In choosing a battery for any purpose, we have to consider its two constants with reference to the external resistance it is to be used with, and in choosing a galvanometer we have exactly similar considerations to deal with.

For galvanometers of the same kind wound with coils of the same size, where the only difference is in the diameter of the wire wound on the bobbins, we may assume S varies as $\sqrt{g}$, and in this case the value of $\dfrac{S}{g + R g}$ will be a maximum when $g = R g$; or we must choose a galvanometer of resistance equal to that of the external resistance of the



galvanometer circuit. Thus, in a Wheatstone's bridge, when balanced, where

$$R g = \frac{(q + s)(p + r)}{q + s + p + r},$$

the galvanometer should have a resistance equal to the parallel resistance of the branch circuit connecting the terminals of the galvanometer.

If the galvanometer be a Thomson galvanometer with four coils of aproximately equal resistances, we can, by

different arrangements of the coils in series or in parallel, alter the resistance of the galvanometer in the ratios 1 : 4 : 16, while the sensibility is simultaneously increased in the ratios 1 : 2 : 4. Thus, if the four coils together have a resistance of 10,000 ohms, we can, by putting two pairs of coils in parallel, diminish the resistance of the galvanometer to 2,500 ohms, while the sensibility will be reduced to one-half its previous value. The value of $\frac{S}{g+Rg}$ will increase if R g is less than 2,500. Similarly we can, by putting all four coils in parallel, diminish the resistance of the galvanometer to 625 ohms

Maxwell's Method of determining Self-Induction.

If in one of the arms s of the bridge be placed a coil of wire having a coefficient of self-induction L, then while the current C s is changing, there is an additional electromotive force acting in the branch s of amount equal to

$$L\frac{d\,C\,s}{d\,t}.$$

The current through the galvanometer will accordingly be

$$C\,g = \frac{E\,b}{R\,b\,g} - \frac{L\frac{d\,C\,s}{d\,t}}{R\,s\,g}$$

If the bridge is balanced for steady currents, R $b\,g$ = infinity, and $C\,g = -\frac{L}{R\,s\,g}\frac{d\,C\,s}{d\,t}$.

The quantity flowing through the galvanometer while the current is established will be

$$Q = \frac{L\,C\,s}{R\,s\,g};$$

and this will produce a swing θ, which, by the formula for the ballistic galvanometer, will be related to Q according to the equation

$$Q = \frac{H}{G}\frac{\tau}{\pi}\sin.\ \tfrac{1}{2}\,\theta,$$

τ being the period of the galvanometer, and H and G being constants.

If, now, we alter the resistance of the branch s by an amount σ, and observe the steady current through the galvanometer we know by (5) that this current is exactly the same as would be produced by an extra electromotive force, σ C s, acting in the branch s.

The current produced by this will be

$$C\,g = \frac{\sigma\,C\,s}{R\,s\,g},$$

and this will produce a steady deflection, α, according to the equation

$$C\,g = \frac{H}{G}\tan\alpha.$$

By division we obtain

$$\frac{Q}{C\,g} = \frac{\tau}{\pi}\,\frac{\sin\frac{1}{2}\,\theta}{\tan\alpha} = \frac{L}{\sigma}$$

or

$$L = \sigma\frac{\tau}{\pi}\,\frac{\sin\frac{1}{2}\,\theta}{\tan\alpha}.$$

In Aryton and Perry's method the discharge Q takes place n times per second, producing a current n Q, which is balanced by making the current due to the derangement σ equal and opposite to it. This will happen when

$$n \times \frac{L\,C\,s}{R\,s\,g} = C\,g = \frac{\sigma\,C\,s}{R\,s\,g}$$

$$\text{or } L = \frac{\sigma}{n}.$$

In Prof. Silvanus Thompson's modification of Joubert's method of determining self-induction the galvanometer and battery circuits are always closed, and an alternating electromotive force is inserted into the battery circuit by means of an induction coil. In this case we have

$$C\,g = \frac{E\,b}{R\,b\,g} - \frac{L\frac{d\,C\,s}{d\,t}}{R\,s\,g}$$

$$C\,s = \frac{E\,b}{R\,b\,s} - \frac{L\frac{d\,C\,s}{d\,t}}{R\,s\,s}$$

These two equations are sufficient to determine the solution when E b is given. We may assume that if there are n alternations per second

$$E\,b = E\sin 2\,\pi\,n\,t,$$

where E is the maximum value of the E.M.F.

By solving the two simultaneous differential equations, and determining the condition that the mean square of the current through the galvanometer branch shall be a minimum, it may be shown that

$$2\,\pi\,n\,L = \sqrt{\sigma\,R\,s\,s},$$

where σ is the apparent alteration of the resistance of the branch s for steady and alternating electromotive forces in the battery circuit.

In problems involving alternating currents contractions similar to those used above have necessarily to be used in order to save time. The advantage of using the resistance ratios consists in the fact that they are the most natural ones to use; they are those which make the equations simplest; they have a simple physical meaning; and in practical cases their values can always be approximately obtained by mere inspection of the network, in much the same way as the walking distance between two places in London can be guessed at by inspection of a street map.

JUVENILE LECTURES.

BY W. H. PREECE, F.R.S.

(Concluded from page 155.)

The next purpose that electricity is used for, to which I want to draw your attention, is that of the transmission or propulsion of coaches on railways. I have taken the trouble to find out the various railways and tramways in America, in Great Britain, and on the Continent, that are now worked by means of electric currents. Here is a list of them :—

ELECTRIC TRAMWAYS IN AMERICA.

The American *Electrician and Electrical Engineer* gives the following list of electrically-worked tram lines now in actual operation in the United States :—

Appleton, Wis., Appleton Electric Street Railway, overhead, 4½ miles, Van Depoele's system, 5 motor cars.
Asbury Park, N.J., Lea Shore Electric Railway, overhead, 4 miles, Daft.
Baltimore, M.D., Union Passenger Railway Company, overhead, Daft.
Bellevue, Pa., ½ mile.
Binghampton, N.Y., Washington Street and State Asylum Electric Railroad, overhead, 5½ miles, Van Depoele.
Denver, Col., Denver Tramway Company, conduit, 4 miles, Short-Nesmith, series.
Detroit, Mich., Detroit Electric Railway Company, overhead, 2 miles, Van Depoele, 4 motor cars.
Detroit, Mich., Highland Park Railway Company, overhead, 3 miles, Van Depoele, 2 motor cars.
Gratiot, Mich., Gratiot Electric Railway Company, overhead, Van Depoele, 1 motor car.
Ithaca, N.Y., Ithaca Street Railway Company, overhead, Daft.
Kansas City, Mo., Kansas City Electric Railway Company, Henry.
Lima, O., Lima Street Railway Motor and Power Company, overhead, 6½ miles, Van Depoele, 7 motor cars.
Los Angeles, Cal., Los Angeles Electric Railway Company, overhead, 5 miles, Daft, 4 motor cars.
Mansfield, O., overhead, Daft.
Montgomery, Ala., Capital City Electric Street Railway Company, overhead, 11 miles, Van Depoele, 20 motor cars.
Port Huron, Mich., Port Huron Electric Railway Company, overhead, 2¾ miles, Van Depoele, 3 motor cars.
Richmond, Va., Richmond Union Passenger Railway, overhead, Sprague motors.
St. Catherine's, Ont., overhead, 6 miles, Van Depoele.
Scranton, Pa., Scranton Suburban Railway Company, overhead, 2¼ miles, Van Depoele, 3 motor cars.
Wichita, Kan., Wichita Riverside and Suburban Railway Company, overhead, 4 miles, Van Depoele, 6 motor cars.
Windsor, Can., Windsor and Walkerville Electric Railway Company, overhead, 1½ miles, Van Depoele, 1 motor car.
Woonsocket, R. I., Woonsocket Street Railway Company, overhead.

ELECTRIC TRAMWAYS ON THE CONTINENT.

Amsterdam, Cortverloren Park, overhead, ½ mile, Siemen's system, steam.
Berlin, Lichterfelde (Berlin-Anhalt Railway), rails, 1·6 mile, Siemens, steam.
Brussels, tramways, accumulators (Julian), steam.
Charlottenburg, Spandauer Rock, overhead, Siemens, steam.
Cologne, tramways, E.P.S. accumulators (Hüber).
Frankfort-on-Maine, Frankfort to Offenbach Railway, overhead, 4·1 miles, Siemens, steam.

Hamburgh, tramways, E.P.S. accumulators (Hüber).
Hohenzollern, Hohenzollern Colliery (Upper Silesia), overhead, ½ mile, Siemens, steam.
Vienna, Moedling-Hinterbruel (Austrian Southern Railway), overhead, 2·8 mile, Siemens, steam.
Zankerode, Zankerode Mines, Saxony, overhead, ½ mile, Siemens, steam.

ELECTRIC TRAMWAYS IN GREAT BRITAIN.

Blackpool, Blackpool Tramway, buried central rail, 2 miles, Holroyd Smith's system, steam.
Brighton, Brighton Beach, rails, 1 mile, Volk, gas.
Brighton, Brighton and Shoreham Tramway, 4 miles, Electric Traction Syndicate (accumulators), steam.
Glynde, Glynde Clay Pits, open, 1 mile, telpherage, steam.
London, North Metropolitan Tramways (Stratford and Manor Park), 4 miles, Elieson (accumulators), steam.
Newry, Bessbrook and Newry, raised central rail, 3¼ miles, Hopkinson, water.
Portrush, Portrush and Bushmills, raised side rail, 6 miles, Siemens, water.
Ryde, I.W., Ryde Pier, rails, ¾ mile, Siemens, gas.

You will see how greatly and how rapidly this great power that electricity gives us is being utilised for useful purposes. One of the earliest lines upon which the power was used was the Portrush and Bushmills Railway in Ireland. But the most complete and most perfect railway of its kind has lately been carried out by Dr. Edward Hopkinson, Sir William Siemen's assistant in carrying out the Portrush Railway. I refer to the Bessbrook and Newry Electric Railway.

Another application of electrical power tried at the Paris Electrical Exhibition was carried out by M. Tissandier, who attempted to navigate a balloon by its means. The balloon worked satisfactorily inside the exhibition building, but failed when tried in the open air.

A very curious departure from the ordinary practice of conveying materials was started by Professor Fleeming Jenkin, who is, unfortunately, now no more, and he, in conjunction with Professors Ayrton and Perry, started a system called telpherage. Not far from Lewes, a mile or mile and a quarter from the Glynde railway station, in the Downs, there are certain clays which are valuable, and from the clay pits the clay is sent down to Newhaven for shipment abroad. This system of telpherage carries the clay from the pits to the station by means of electricity. Two heavy wires are fixed on cross-beams, or posts, which pass over the meadows, they do not interfere with the roads or the grazing of cattle, they pass over bogs, marshes, rivers, and anywhere you like, and on these wires skeps—a kind of bucket—are carried on rollers, by which they pass along. Each skep carries about half a hundredweight of stuff. The arrangement is extremely ingenious, and daily and hourly trains pass by this means over the Downs to Glynde Railway Station carrying the clay. Such is the telpherage system.

But there is one system of carriage where electricity is destined to become more useful and more valuable than any other that I have brought before you, and that is in the working of a system of tramways in towns. There are few people who know that the number of horses required to work a tramway is 12 per car. My figures are taken from Manchester, where there is one of the best worked systems of tramways that we have in this country. There every car requires 12 horses to work it; the life of a car horse on those tramways is only four years. Working tramways in the north, wherever there are heavy gradients, is really cruelty to animals. We know that a horse can only do a horse's work; there are some men who can do a good deal more than an ordinary man's work, but we rarely should expect any man to do more than five or six men's woık. But these tramway horses are absolutely frequently called upon to do eight or ten times more than nature has constructed them to do, and it is no wonder that their life is so very short. This remarkable fact comes out in dealing with horses from a pure matter-of-fact point of view. If we work a tramcar by electricity by means of batteries placed in the car, taking the price of horseflesh and the price of batteries per ton, the cost is exactly the same—it requires a ton and a half of horseflesh, it requires a ton and a half of batteries, to work a car. The life, as I stated, of a car horse is four years, the life of a battery is four years. A horse will hardly do more than thirty miles a day; a battery will carry a car for sixty miles a day, and, in fact, when we remember that for the price of two horses, for the life of two horses, we can work tramcars by means of electricity, then when you think that it takes 12 horses, the mere question of £. s. d. will carry the day. There is not the slightest doubt that, when the matter is properly and thoroughly worked out in a practical manner, batteries can and will work tramways, and the day is not far distant when all our tramways in and about London will be worked by means of batteries, and the poor horses relegated to duties for which they are better fitted.

We will now go back to some of the other purposes, and the one purpose that I wish to refer to is the power that electricity gives us to utilise the waste powers of nature. Wind, tides, and falling water are to be found everywhere, and if they can be utilised economically will certainly be so used. I have shown you, in the case of the Portrush Railway, how water power is utilised in this way. In the Bessbrook and Newry Railway, water power is utilised in precisely the same way. At Craigside, near Newcastle-on-Tyne, Lord Armstrong is able, by means of the energy of a waterfall in his grounds, to light up his house and to do various other things. In France M. Felix has used this same property for ploughing. You will see on the screen a picture of the way in which the power of electricity is so used.

There is another application of electricity that has been attracting a good deal of attention at Brighton. Mr. Volk, who has done a great deal towards the application of electricity down there (he has laid an electric railway along the beach), has started an electric dog-cart. He has fitted a dog-cart with batteries, and it goes bowling about Brighton without a horse. He, his wife, and daughter, are to be seen taking their airing along the Parade in a vehicle that looks like a dog-cart, but there is no horse in it.

Electricity is also used for propelling boats, and you see a picture of the "Cygnus," a boat used at the Paris Electrical Exhibition of 1881; a little Trouvé motor works the screw. Now you see a picture of the boat "Electricity,' and the rate at which these boats are propelled is pretty considerable. There is a diagram on the table of the electric launch recently tried at Havre by the French navy; it is not a very elegant-looking boat, but I believe it goes with great velocity, and gives satisfaction. I have had the pleasure of going up the Thames in an electric boat made for the Duke of Bedford, and I have been up the Danube in another electric boat. I am looking forward to the time when we may have electric boats on the Thames. It only wants some enterprising firm to establish machinery at charging depôts at Teddington, Rèading, and other places, to enable boats to be propelled by electricity.

All the applications of electricity that I have shown you have been by way of peaceful purposes, but the same power can also be used for the destruction of our enemies. I have here a miniature ship in a bath containing water. It represents a pirate vessel with its black flag and skull-and-cross-bone ensign flying, sailing along seeking its prey. On the pan containing the water there are two marks, and when the boat gets between them I know it is in the vicinity of a submerged torpedo, and on sending an electric current the torpedo explodes and blows up the ship and all its crew to destruction. That concludes the experiments that I intend to show you.

I have shown you various ways in which it is possible, by the proper utilisation of electricity, to economise labour; but there is always this fear, that if too many means of economising labour are introduced it may lead to idleness and evil. Still, when labour is saved in one direction it is given in another direction, and the result must evidently be beneficial in the long run.

I have brought before you some effects of one of the great powers of Nature, and I have shown you in these two lectures, in a very rough and hasty manner, how it is applied to useful purposes. Every single purpose which I have shown you was in itself deserving of a lecture occupying a whole evening; but, however, to the best of my ability I have endeavoured to bring these matters before you, and I have been assisted in them by the very generous way in which others have come to my help. My friend Mr. Lant Carpenter has helped me considerably: Mr. Probert, Mr. Heather, Mr. Davenport, and others have all assisted, as have Messrs. Immisch and Binswanger with apparatus.

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

HOUSE TO HOUSE.

We have long held the idea that company-mongering was a curse to electric lighting; and, holding these opinions, it will not be a matter for surprise that we feel it a duty which we owe to the public to protest against contributing towards the share capital of a company registered under the euphonious title of The House-to-House Electric Supply Company. There are companies and companies. Some are legitimately promoted, and fill a useful sphere of operation, others are merely pot-boilers to company promoters. It is unfortunate that in writing of this company we must necessarily criticise, somewhat sharply, Mr. Hammond, who seems to be the moving spirit. Mr. Hammond is not unknown to electric light fame, but history as yet fails to record any achievement of this gentleman which can be said to have contributed to the prosperity of the industry. According to the advertised prospectus Mr. Hammond is to get £5,000 cash, £5,000 ordinary shares, and the whole of the 100 founder's shares. For what is this money and these shares to be given? The answer is: the receiver "is to give his services as managing director without remuneration for two years," and to "bind himself for five years not to become associated with any other undertaking for the supply of the electric light unless by consent of this company." Now with all due deference to Mr. Hammond, we deliberately say there is no man living, or that ever has lived, who is worth £5,250 a year as managing director to a company of this sort. The company is bound to fail before it commences operations, and might as well hang a millstone round its neck before taking a leap into the sea as to agree to such terms as these. The prospectus of this House-to-House Supply Company is trading upon the so-called success of the Brighton Company, and we read "One of the founders of this company having some time since established the Brighton Electric Light Company, which, although upon a small scale, has proved very successful, and its business is rapidly increasing," which makes us ask if intending subscribers have made themselves acquainted with the whole history of the Brighton Company. We will not enter into that history, though it is very instructive, further than to ask what has been the total capital spent at Brighton from the earliest day, not the capital of the present company, but the whole; and to say that the existing company, in our estimation, owes whatever success it may have obtained to the ability of the Brighton manager—Mr. Wright—and to no one else. We are not inclined to go into ecstacies over this success. We have some recollection of feeling dissatisfaction with the make up of the previous balance sheet, but if the shareholders were satisfied, too low a rate of depreciation was nothing to us. The report of

the Brighton Company, as given in our last issue, is to our obtuse understanding not so very flowery. Its value very largely depends upon that "ample sum for depreciation," of the amplitude of which we are unable to judge, as neither the amount nor the rate per cent. is forthcoming.

The public is asked to find a first instalment of £175,000 in 35,000 shares, because, in reply to circulars, people have asked for some 14,000 lights. Such statements as this are to the initiated valueless; to the uninitiated they may prove a delusion and a snare. How are these 14,000 lights distributed? Are they all in one district, and even then over what area, or are they in several districts, or scattered throughout greater London? The answer to such questions would at once give a clue to the commercial value of these requests for light.

There is still one return unmentioned, which Mr. Hammond is to make for the money and shares to be handed over to him, viz., "To secure for the company, on the most favoured terms, a license to use a meter for measuring alternating currents, which has already been in practical use, and has given highly satisfactory results." Are we to believe that any patentee or manufacturer in his sober senses is going to favour Mr. Hammond over any other individual presiding over a large company? Is there only one meter in the market, and is Mr. Hammond going to get the sole right over the best meter? If not, what is the value of this promise either in cash or shares?

It will be said that we are writing against the electric light. We are doing no such thing. We are doing what every technical and commercial paper ought to do, attempting to save the public from losing its money. At the end of the lighting boom in 1882, companies had been floated with a total capital of over £20,900,000, nearly twenty-one millions of pounds, and if the public was not swindled out of the greater part of the cash collected under cover of these companies, we should like to know how to designate the result of the company mongering. We are ready by word and by deed to assist to the utmost of our ability companies which seem to have promise; but here is one that has neither promise, patents, nor works. The public is asked to shut its eyes and give. We contend that if it does give it will be in the sure and certain hope of realising a heavy loss.

If householders and others are so anxious to get 14,000 lamps installed into their factories and houses, there are a score of firms in existence at this moment able to do the work better and cheaper than any limited liability company floated on the lines of this prospectus.

In conclusion, while we have the highest opinion of the correctness of the legal statement as to the powers to run overhead wires without infringing the Act of 1882, we do not forget that as soon as electric light wires and telephone and telegraph wires become a little mixed overhead, and a snow or wind storm brings about a general breakdown and an indiscriminate series of contacts, then, Act or no Act, powers vested in local authorities or no such powers, overhead wires are doomed.

The householder who grants way-leaves for leads carrying 2,000 volts over his house does so through ignorance, and so soon as he is made fully aware of the danger through leakage or accidental contact, he will withdraw his permission. The danger with a multitude of telephone or telegraph wires is small in comparison to the danger of a mixture of these wires with electric light wires. The immunity of Brighton to accident will no doubt be put forward; but what are the fifteen miles there compared with the length required in any general lighting in London?

ELECTRIC LIGHTING IN THE CITY.

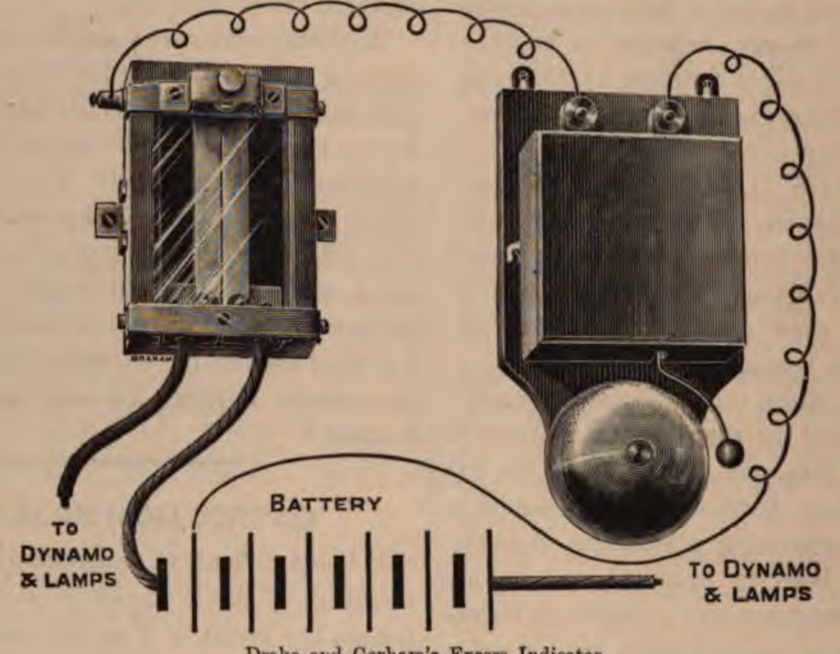
It is not difficult to understand the position of the members of the Commission of Sewers, but nevertheless the result of Tuesday's meeting, as reported elsewhere, is disheartening to all engaged in the electric lighting industry. We are not in a position to fully discuss the figures reported to have formed the communication of the Maxim-Weston Company, because the information is as yet very meagre. Our opinion, based upon the facts of the case so far as we know them, is that the Maxim-Weston Company has put in figures at which it is absolutely impossible to do the work satisfactorily, and that this action has consigned a well-considered, well-matured scheme to possible failure. It cannot for one moment be considered by those who know anything about electric lighting, that the Brush Company's terms are high; but on the contrary, surprise has been expressed that they were so moderate.

Returning to the Maxim-Weston proposal to put up 800 lamps to light the whole City, in place of the 3,000 gas lamps at present existing, the former to give 300,000 c.-p. in place of the 60,000 c.-p. of gas. The initial cost of these 800 lamps, and we suppose this includes generating station, wiring, dynamos and engines, is to be less than £15,000, and the maintenance of each lamp less than £5 per annum. We will believe it when we see it, but not before. The proposed lamps, no doubt, are wonderful things, but they burn carbons, and carbons cost money, more money than will permit this estimate being taken as correct. There *must* be some mistake somewhere, and before dealing further with this matter we await enlightenment.

Book Received.—"Turning Lathes: A Manual for Technical Schools and Apprentices," with 194 illustrations. Edited by James Lukin, B.A. London: E. and F. N. Spon.

DRAKE AND GORHAM'S EXCESS INDICATOR.

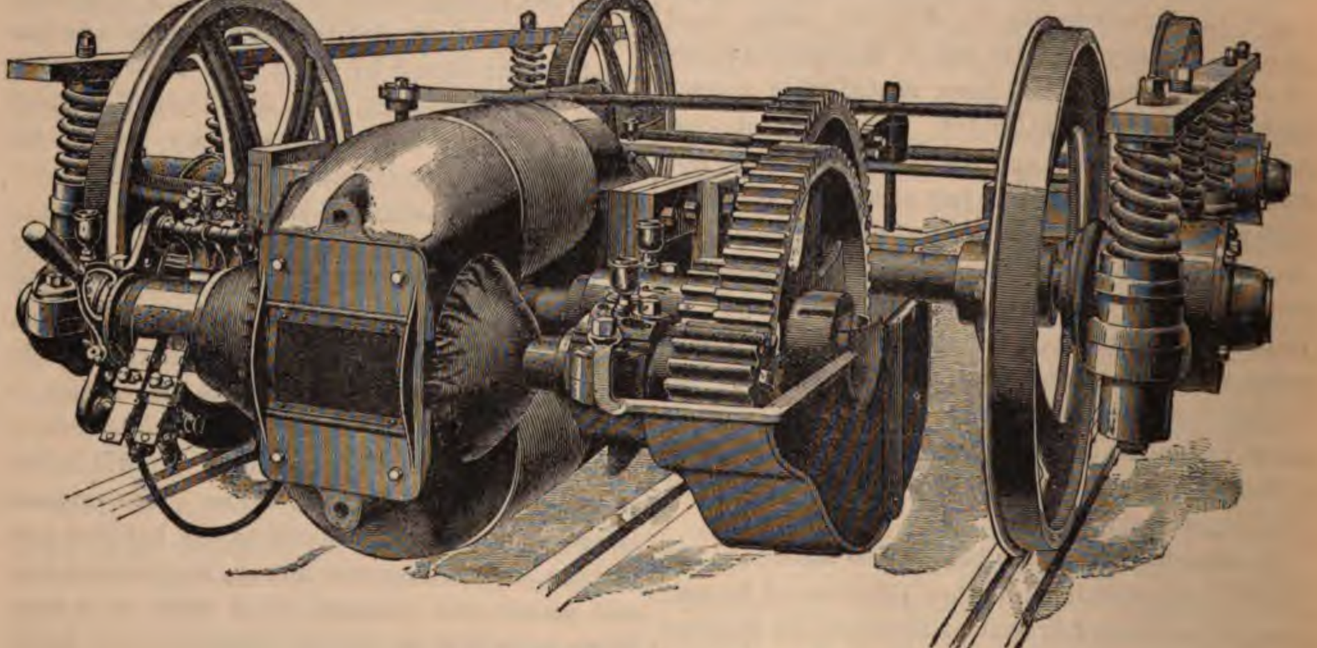
It has long been acknowledged that nothing tends more to lower the efficiency and diminish the life of an accumulator than the strained action attending rapid charge or discharge. The liability of exceeding the normal rate might be obviated by the use of an automatic cut-out, but in most installations the sudden extinction of the light would be quite inadmissible. The apparatus illustrated has been found to meet the requirements of a reliable excess indicator. It is so arranged that whenever the current exceeds the proper limit an electric bell comes into circuit, and continues ringing until the normal conditions of working are restored. The principle adopted is that of the thermic alarms, which depend for their action upon the bending of a compound metallic plate under variations of temperature. In this case a strip or plate consisting of two metals rolled or soldered together, has a narrow slit cut across its centre, thus forming a narrow flat U piece, the ends of which are rigidly held and connected to terminals, which are placed in the main circuit. The closed end of the loop is free to move, and carries a carbon stud. Immediately opposed to this is a similar stud, to be connected through an ordinary electric bell to one of the cells in such a manner that when the two studs make contact the current from one cell only will pass through the coil of the bell. The distance between the two contracts is adjustable. The tendency of the current in passing round the loop is to cause the parts carrying the contact stud to bend upward, and should the pre-arranged limit be exceeded, alarm is immediately given by the bell, which may be fixed at a distance if required. The alarm is found to be practically constant and reliable, variations in the temperatures of the atmosphere being inappreciable in effect.



Drake and Gorham's Excess Indicator.

THE BENTLEY-KNIGHT ELECTRIC RAILWAY SYSTEM.

We illustrate on this page the standard Bentley-Knight motor truck as it appears before the car body is mounted. It is entirely independent of the car body, and can be put under any existing car without cutting or alterations, and without lifting the car above its normal height. The motor is controlled from either end of the car, the only connection necessary being a chain attached to the ordinary brake spindle. By this arrangement the whole control of



The Standard Bentley-Knight Motor Truck.

the car is from the ordinary handle. Turned in one direction it throws off the brake and starts the car, while, turned in the opposite direction, it applies the brake and stops the car. The weight of the motor is concentrated on the driven axle, so that the tractive adhesion is ample at all times. The motor has a spring support, so that wear on working parts and on the track is very light, while it also permits a yielding impact of the motor on the load at starting.

Tooth gearing is used throughout, and all journals are held in rigid casings. The gearing is guaranteed to be noiseless, efficient, reliable, and durable. The brakes are hung from the truck, not from the car body, and there is, therefore, no jarring felt by the passengers when brakes are applied. The motor has been designed especially by the Thomson-Houston Electric Company. The commutator brushes are fixed in position, and need no adjustment, either for change in load or direction of rotation. The motor, therefore, requires but slight attention, and can be put under the car with perfect safety. There is no flashing or sparking under the heaviest load. But one set of commutator brushes are used, and they are adapted for either direction of rotation.

There is no heating of the motor, as it has but one layer of wire on the armature, and but a small amount of coarse wire on the field magnet. The armature is encased in oiled silk, and is moisture-proof. All journal boxes are self-oiling and dust-tight, and the gearing is encased in a dust tight boxing.

The truck shown is one of those built for the North and East River Railway, of New York City, the tracks for which are now laid through Fulton Street. It is hoped that the legal obstructions which have prevented the laying of conduit will be shortly removed, and that this road will be in full operation in the early spring. The Thomson-Houston motor, mounted on the truck as shown in the illustration, will give from 15 to 25 h.-p. economically. The very heavy curves, grades, and traffic of Fulton-street necessitated ample provision of power.—*Electrical World.*

ON THE POSITION AND PROSPECTS OF ELECTRICITY AS APPLIED TO ENGINEERING.*

BY MR. WILLIAM GEIPEL, OF EDINBURGH.

(Continued from page 131.)

II. Electric Locomotion.

The practical methods of accomplishing electric locomotion seem to the author to be the four following:—

Firstly, the use of a third insulated rail or conductor to convey the current from the generator to the motor carried on the locomotive, contact being made by a wheel or a sliding spring or brush; while the two ordinary rails serve as a return circuit, the current being conducted from the motor to the rails through the frame, axle, and wheels of the locomotive.

Secondly, the employment of an overhead conductor supported on poles or from the roof of an arch or tunnel, contact being made either by a carrier on wheels running along the conductor, or by rubbing. The return circuit may be either through a second overhead conductor, or through the ordinary rails as in the third-rail plan.

Thirdly, the use of an underground insulated conductor, placed in a conduit between the rails, and conducting the current from the generator through a contact carriage to the motor, whence it is conveyed back through the frame, axle, wheels, and rails.

Fourthly, the employment of storage batteries, placed preferably under the seats of the car, with the motor and gear underneath, or the whole placed on a separate locomotive.

The plan of using the ordinary rails as positive and negative conductors, and insulating the wheels or axles of the cars, is attended with the objection that, owing to the rail supports having to carry heavy loads, there is difficulty in insulating the rails sufficiently to prevent excessive leakage to earth.

* A paper read before the Institution of Mechanical Engineers, February 2, 1888.

Of these four methods the first two are the cheapest and most efficient, but are applicable only to railroads; while the two other plans, of an underground insulated conductor, and of storage cells on the cars, are both applicable to street tramways.

Gearing.—Owing to the high speed at which electric motors require to run and the limited space available for them to occupy, the mode of gearing the motor to the axle of the locomotive or car forms an important consideration, more especially in places where the motor is placed upon the car which carries passengers, when noise and vibration would be most objectionable. The following five methods of gearing are those more generally employed:—(1) worm-wheel gearing; (2) pitch-chain gearing; (3) leather belting; (4) rope, either endless or not; (5) toothed wheels.

Worm gearing appears from Mr. Holroyd Smith's experience at Blackpool, where his electric tramway is worked with an underground conductor, to be the best for tram-cars. Although as a rule it is not efficient, yet if well designed and properly lubricated it can be rendered more efficient, and probably is fairly suitable for this purpose. Some tests made by Mr. Reckenzaun show a maximum efficiency of 87 per cent. The author thinks that a combination of toothed wheels and friction gear, such as has been introduced by Mr. Raworth for driving dynamos in electric lighting with excellent results where space is a desideratum, would make a silent working and durable form of gear: the friction gear would serve to reduce the speed from the motor to a countershaft; and from the latter the driving wheels of the car would be driven by toothed wheels. The form of gear employed of course depends greatly upon the nature of the traffic and of the rolling stock.

Third Insulated Rail.—As an example of an electric railway with a third insulated rail, that at Portrush, Ireland, is probably the most interesting, as being one of the first started in the world and also the longest. It was planned by Messrs. Siemens, and its total length is six miles. Power is generated by two 50 h.-p. turbines, driving a dynamo which is capable of generating 100 amperes at 250 volts; the current is transmitted from the river Rush through a distance of 1,600 yards to the railway, the resistance of the line being 1·9 ohm. Pitch-chain gearing is used, and gives satisfaction. The working expenses amount to less than threepence per car-mile.

Another instance, also in Ireland, is the Bessbrook and Newry tramway, which is three miles long and three feet gauge, and is actuated by water power. The photographs exhibited, showing the arrangement of the cars, have been kindly lent by Dr. Edward Hopkinson, to whose designs the railway was constructed. A turbine which develops 62 h.-p. drives two Edinson-Hopkinson dynamos, each capable of giving out 25 h.-p. at 250 volts. The third rail is of channel-section steel, supported in wooden blocks which apparently act admirably as insulators, the leakage being only ¼ ampere per mile, or 0·3 h.-p. in all. A train consists generally of one passenger car, constructed to carry thirty-eight persons, and three goods wagons, each carrying two tons freight. The maximum speed that can be attained is 15 miles per hour. Here, also, chain gearing is employed. The cost per train-mile is 3·3d. during the busy months, and 4·2d. in slack months; these figures, however, do not include anything for depreciation on the cost of construction of the railway, which was £2,500, nor for general supervision.

Overhead Conductors.—The electric railway at Moedling, near Vienna, is a good example of the employment of overhead conductors. The number of passengers carried during the year 1886 was 342,257, according to Mr. Reckenzaun, and the average cost 3·42 pence per car-mile; the coal consumption per car-mile was 13·4lbs. of very inferior brown coal. The current is generated by six Siemens dynamos, driven by three portable engines of 12 nominal h.-p. each; the use of these engines may account for the somewhat high consumption of coal. The overhead conductors, which are carried on posts 18ft. high and 90ft. apart, consist of slotted tubes in lengths of 15ft. each, soldered together; a contact carriage slides within the tube, which is 1in. diameter inside. Spur gearing is used, but apparently is not satisfactory; the objections to it are the rapid wearing out of the high-speed pinions, the great weight of the gear, and the noise and vibration caused.

The Frankfort Offenbach electric railway, which was opened for traffic on 10th April, 1884, is similar to that at Moedling, the current being brought to the moving cars by means of slotted iron-tube conductors carried overhead. The length of the line is about 4½ miles; the gauge is 1 metre (3ft. 3⅜in.). The sharpest curve has a radius of 98½ft.; the steepest incline is 1 in 30, and only 18 per cent. of the line is level. The average speed of the cars is 7½ miles per hour. Two cars coupled together start from each end of the line every twenty minutes. Each car has seats for eighteen passengers, and standing-room for twelve more, the gross weight being 4 tons. The motor is placed under the floor of the car, and the connection to the wheels is made by toothed gearing. The generating station is at Ober-rad (about the middle of the line), and contains one twin engine of 240 i.h.p. and one spare engine of 80 to 100 i.h.p. In regular work one cylinder only of the twin engine is used, giving off 120 i.h.p. The current is generated by three Siemens dynamos, called 300-light; a fourth similar dynamo is in reserve. The working electromotive force is 350 volts. The current generated by the three dynamos is sufficient to keep eight cars running simultaneously.

This plan has been most largely adopted in America, where there are probably not far short of one hundred electric railways at work and projected. It has certainly the recommendation of cheapness, for a higher voltage is permissible, and consequently a smaller conductor with less loss of power than in the case of the third rail; this is more especially important for long lines. As an instance of what is being done, a railway of eleven miles in length is now in course of construction at Richmond, and forty cars are building to be worked upon it on the overhead system. Another instance is the railway at Scranton, Pennsylvania, which has been in successful operation about a year. It is four miles and a half long; five cars carrying motors from 15 to 20 h.-p. are in use, and four cars with 25 h.-p. motors are being constructed, each of which will be able to draw two others; the cars carry 75 passengers each. The current is generated by two 100 h.-p. dynamos driven by two 180 h.-p. engines, one set being spare: the potential adopted is 600 volts. The overhead conductors are of copper $\frac{5}{16}$ths inch diameter; the supporting poles are 100 feet apart, about 20 feet high, and about six inches diameter at the thick end; the return circuit is through the ordinary rails. The plant is also used for lighting the town. The potential generally employed in America for the longer lines is from 500 to 600 volts; the latter is probably the limit to which it is safe to work. With this potential two ⅜ths inch copper conductors would serve to work twenty-five cars in parallel, the current per car averaging about 10 amperes. With a voltage as high as this the leakage on the third-rail system would be excessive.

Underground Conductor.—Perhaps the most important example of this plan is Mr. Holroyd Smith's electric tramway at Blackpool, which has been in successful operation for some two years. The underground conduit is somewhat similar to that of a cable tramway such as is working at the present time in Edinburgh and on Highgate hill, London; but instead of the carrier being used to grip a running cable, it is made to rub along a stationary conductor. The cost of working is stated to be less than fourpence per car mile; during one week in the season of 1886 there were 44,306 passengers carried at a cost of £45 for wages and fuel, which is less than one farthing per passenger.

Where an underground conductor is employed, the advantages of having no slit communicating with the surface of the street are so obvious that an ingenious plan has been proposed by Mr. Frank Wynne for placing the conductor in a hermetically sealed conduit under the line. A small carrier which acts as a contact-maker between the conductors and short sections of rails laid in the road, travels along the conduit, being actuated by a tiny electromotor and by part of the same current which works the tramcar above it. An absolute synchronism between the tramcar and the carrier is obtained by a simple device. The short sections of rails are in circuit only whilst the car is over them.

A plan has been proposed by Profs. Ayrton and Perry for making contact between the underground conductor and the section of rail underneath the car, by means of the weight of the car, which actuates an arrangement of levers that make the contact so long as the car is on that section. A plan has also been proposed by them for employing the attraction of a magnet fixed on the car and keepers fixed in boxes underneath the street. The contacts on the keepers are permanently connected with the underground conductor, and when lifted by the attraction of the magnet on the car they make connection with a section of rail, putting the motor in circuit.

Storage Batteries.—Storage batteries on the car have not as yet been much used, though many experiments have been made from time to time. The problem was first attempted by Mr. Reckenzaun, who has done much to perfect the plan. The difficulty is that, if the accumulators are made light, their depreciation is high; while if they are constructed with a thoroughly serviceable make of cell, their weight is very great. The first cost of the cells is also somewhat prohibited, and their depreciation is high. A trial of this plan on a practical scale is now being made by Mr. Elieson on the North Metropolitan Tramway in London. The storage cells are placed on a separate locomotive car. The motor turns itself round on an upright pivot, by means of a bevel wheel on the armature shaft, gearing with a circular rack fixed on the floor of the car; and the revolution of the motor is transmitted to the axle of the car through mitre gear. Trials are also being made in Brussels, in Philadelphia, and in other places; but there appear to be no very reliable data as to the cost of working. The plan has been unsuccessful in the past, owing to the use of inefficient motors and gear, which require of course an increased size of battery in proportion to their inefficiency; the imperfection of the secondary batteries employed, as pointed out, has also prohibited success. With motors, speed-reducing gear, and secondary batteries all improved, the experiments now being made bid fair to demonstrate the successful working of tramways by electricity in crowded thoroughfares.

Ordinary Rails as Conductors.—The short electric railway of Mr. Volk at Brighton on this system is interesting as being one of the earliest in use in this country. The expenses amount to twopence per car-mile, being made up as follows:—

Gas for engine	1·11 penny.
Wages	0·70 ,,
Oil and waste	0·07 ,,
Repair	0·12 ,,
Total per car-mile	2·00 pence

The total car-miles per annum are stated to be 47,000, and the depreciation at 10 per cent. on the £3,000 cost of construction is therefore equal to 1½ penny per car-mile, thus bringing up the total cost to 3½ pence per car-mile. Several similar railways are now working or contemplated in seaside towns.

Cost of Working.—From these instances it will be seen that, taking into consideration the fact that the machines here employed are not so efficient as those now being made, an electric tramway may be worked for about threepence per car mile; and as the cost of horses is from sevenpence to ninepence per car mile, the importance of electric propulsion for tramcars and short railways is very evident. At the Antwerp Exhibition in 1885, when electric locomotion was beginning to receive consideration in its commercial aspect, a series of trials extending over four months on five different kinds of tramway motors resulted in the first place being assigned to the electric car, in competition with the four following plans:—The Krauss and the Wilkinson locomotives separated from the car, the Rowan engine and car combined, and the Beaumont compressed-air car. The results of these trials are given in Table III.

Notwithstanding that the use of electricity for heavy railway traffic has been predicted, the author thinks that, so long as the electricity is generated by dynamos driven by steam engines, steam locomotives will not be discarded in favour of electricity for long distances. But for light railways and suburban lines, underground or overhead, where the use of a steam engine is a nuisance, there can be little doubt that electricity must be largely adopted in the immediate future, as the number of such railways already

constructed and in course of planning is now between one and two hundred.

TABLE III.—*Trials of Tramway Motors at Antwerp Exhibition, 1885.*

Description of Motor	Electric	Rowan.	Wilkinson.	Krauss	Compressed Air.
Train-miles run..........total	2,359	2,617	2,473	2,458	2,259
Consumption of Fuel. total ....lb.	14,786	14,498	22,000	22,726	90,420
Consumption of Fuel. per train-mile, lb.	6·16	5·42	8·82	9·10	39·48

Underground Haulage.—Electricity has been applied to haulage in various mines. A locomotive car, worked by a current sent through a conductor fixed along the side or the roof of an underground road, could be employed economically wherever the traffic is large and the distance considerable; but there is the objection of requiring a heavy locomotive car, in order to get sufficient tractive power for starting a train of tubs.

(To be continued.)

LITERATURE.

Berly's Universal Electrical Directory and Advertiser. The electrician's "Vade Mecum," containing a complete record of all the industries directly or indirectly connected with electricity and magnetism and the names and addresses of manufacturers in Great Britain, America, the Continent, &c. Published by W. DAWSON and SONS, 148-9, Upper Thames-street, E.C.

We have received the new edition of this well-known directory, which has been corrected to date. An alteration in this edition is that the continental section has been translated into English, so as to facilitate reference. This directory differs from any other of the kind in that it pays far more attention to the obtaining of a trustworthy Continental and American list of names of those interested in the electrical industries. Of course, the great value of a book of this kind is in its completeness and the completeness of its cross references, and great efforts seem to have been made that this edition shall be satisfactory in both these instances.

CORRESPONDENCE.

PATENTS AND EXHIBITIONS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR: Referring to the notice in your issue of last Saturday respecting the Glasgow Exhibition, and in view of the several other exhibitions to be held this year in Brussels, Vienna, Munich, Melbourne, and elsewhere, will you kindly allow us, through the medium of your space, to caution investors against the danger of exhibiting *unpatented* inventions, under the 39th Section of the recent Patents Amendment Act.

This section is one of the most misleading character, for while it purports to protect the invention during the exhibition, and to secure to the inventor unprejudiced rights against others, it now transpires, by recent decisions in the Law Courts, that the legal interpretation of the section is that it merely affords protection to the inventor, as against *his own* acts, and that he is not protected against others copying, if they choose, his invention.

According to this interpretation it is injudicious for any inventor to exhibit under the section in question, for while he no doubt acquires protection against the consequences of *his own* acts, he is simply exposing his invention for unscrupulous speculators, to pirate and probably deprive him of any benefits he may be entitled to in connection therewith.

The remedy is not to exhibit without first taking out provisional protection—a step which affords all the security desirable under the Patent Law.—Yours, &c.,

J. K. FAHIE AND SON.

Patent Offices, 10, Leinster-street, Dublin; and 323, High Holborn, London, 20th February, 1888.

INSTITUTE OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR: Mr. Walker has spoken to good purpose in suggesting the admission of ladies to our meetings, and the proposition should be well ventilated. The most important thing to determine is the desire of the ladies themselves. Unless I am mistaken, ladies now attend Prof. Ayrton's classes—indeed, Mrs. Ayrton has been lecturing to ladies upon the subject of electricity—and, as Mr. Walker says, the near future will see a large utilisation of electrical apparatus in our houses, so that the more the gentler sex know of the subject the better. Their sewing machines will be run by means of an electric motor, their mincemeat chopped by similar aid, not to speak of lighting, which, if the ladies had their own way, would soon become general. By all means ventilate the question, and if the ladies desire admission, find some method by which their desire shall be granted.—Yours, &c.,

EXON.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Referring to the letter of Mr. Walker which appeared in your columns of last week, in which reference is made to the admittance of ladies to the meetings of the society, I, for my part, should think there could be no reason why ladies should not be admitted, as they are to the Society of Arts, since it would be a great boon to those who are interested in electricity. I hope the subject will be followed up, and that the suggestion will be carried out.—Yours, &c.,

ELECTRICITA.

ELECTRO-HARMONIC SOCIETY.

The first amateur concert of this society will be held at St. James's Hall Restaurant on Friday, March 2nd. We have no doubt the members will attend in large numbers, the programme as arranged being exceedingly attractive:—

PROGRAMME.

Part I.

Part Song........................"The Chapel"........................*Kreutzer.*
The Gresham Quartette.

Song........................"The Devout Lover".........*Maude V. White.*
Mr. T. H. Harrison.

Aria....................."O, del mio dolce Ardor"...............*Stradella.*
Mrs. A. Siemens.

Piano Solo............"Romance in F sharp (No. 2)".........*Schumann.*
Mr. James Swinburne.

Song.............................."La Serenata"...........................*Braga.*
(Violin obligato, Mr. T. E. Gatehouse.)
Miss Mary Doughty.

Song....................."Salve Dimora" (*Faust*)..................*Gounod.*
Mr. S. Jaronski.

Song........................"A Kiss and Good-bye"...............*Tito Mattei.*
Miss Spagnoletti.

Part Song....................."Chinese March"...........................*Otto.*
The Gresham Quartette.

Part II.

Part Song.................."The Young Musicians"..................*Kucken.*
The Gresham Quartette.

Song....................."Sleep, my Love, Sleep"................*Sullivan.*
Miss Mary Doughty.

Song.............................."My Friend"........................*Behrend.*
Mr. T. H. Harrison.

Violoncello Solo............ *a.* Romance ....*Goltermann.*
b. L'Arlequin. ....*Popper.*
Mr. W. Stepney Rawson.

Song........................"Von Ewiger Liebe"......................*Brahms.*
Mrs. A. Siemens.

Song....................."Celeste Aida" (Aida)........................*Verdi.*
Mr. S. Jaronski.

Piano Solo ...."Minuet from Fantasia Sonata, Op. 78"......*Schubert.*
Mr. James Swinburne.

Part Song ...."When Evening's Twilight"...............*Hatton.*
The Gresham Quartette.

Incandescence Lamp "vacua."—M. Hees has made some experiments to determine the effect, from a photometric point of view, of diminishing the vacuum ordinarily obtained in incandescence lamps. He found, by gradually admitting air, that no appreciable effect occurred until the tension of the enclosed air corresponded to 2 millimetres of mercury; from this point the light, with a given cnrrent, rapidly diminished, until, when the tension was 6 millimetres, the illuminating power fell to one-third of its initial value.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

THE DISTRIBUTION OF ELECTRICITY BY MEANS OF SECONDARY GENERATORS OR TRANSFORMERS.*

BY J. KENNETH D. MACKENZIE, MEMBER.

(Concluded from page 163.)

Two points now claim our attention, as they bear directly upon the question of the dynamo. Shall this yield a current of the potential required in the supply mains? In other words, shall it be a high-potential and small-current dynamo, or shall it be one which gives out a large current at a lower potential? In the latter case it will be necessary to pass this current

FIG. 12.

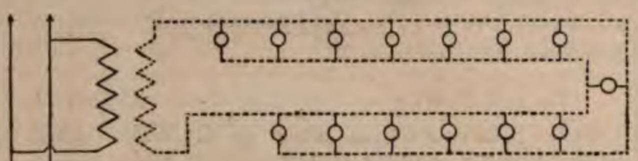


FIG. 13.

through a transformer which will convert the electricity supplied into its required proportions, or, in other words, will raise the potential and diminish the current. In actual practice I do not believe that this application at present exists. I had the advantage of discussing the matter thoroughly in 1884 with Dr. Orazio Lugo, of New York, when he was in this country watching the early experiments of Messrs. Gaulard and Gibbs on the Metropolitan Railway, and we made some experiments which led me to consider such an arrangement advisable in certain cases, and I have no doubt that before long it will be put into use in certain installations now in contemplation. The arrangement is shown in Fig. 16, where, however, two such main transformers are seen coupled together, so as to supply current upon a three-wire system.

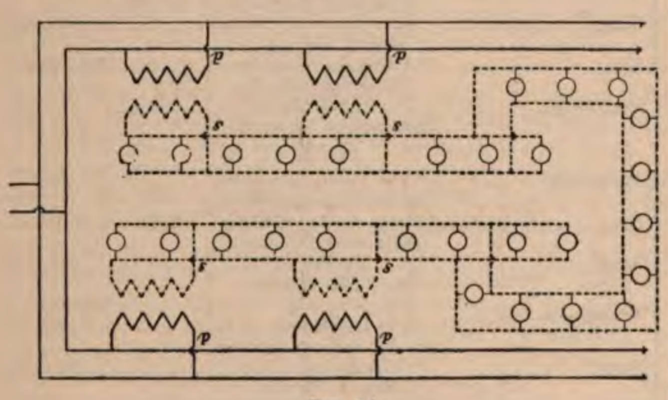


FIG. 14.

I am inclined to believe that this employment of potential-raising transformers, even with their attendant loss in the transformation of the energy, offers advantages over direct working, since the cost of construction of low-potential dynamos is less than that of high ones, and greater reliability may be obtained, as well as more perfect control over the supply into the mains.

Upon this subject, however, makers of alternating-current machines may be able to enlighten us more fully, as the questions involved apply more directly to details of construction in the dynamos. These main transformers can of course be equally applied, whether the other transformers be connected in parallel or series upon the supply mains.

We will now turn our attention to the mains connected to the primaries of the transformers supplying them with current for transformation, as well as those delivering the current from the secondaries. I usually term the former "supply mains," and those which run from the secondaries into the lamp or other receiving system "distributing mains," and as such I will hereinafter refer to them.

Figs. 12, 13, 14, and 15 show theoretically various methods of connecting transformers to the supply mains.

Fig. 12 shows one transformer in parallel arc to the supply mains supplying lamps in parallel.

Fig. 13 shows two transformers coupled together in parallel, and also in parallel with the supply mains, their secondaries being also joined in parallel to the lamp circuit.

Fig. 14 shows several transformers in parallel, their secondaries, being also united in parallel, thus forming a network system of distributing mains.

Fig. 15 shows a three-wire system of distribution, the dynamo having two circuits, and the transformers being placed in parallel across each of the two sets of supply mains. These mains would, of course, be calculated upon the same lines as if an ordinary direct-supply three-wire system were being erected. I do not know whether this application exists in practice, but it would offer advantages in many ways in a large undertaking.

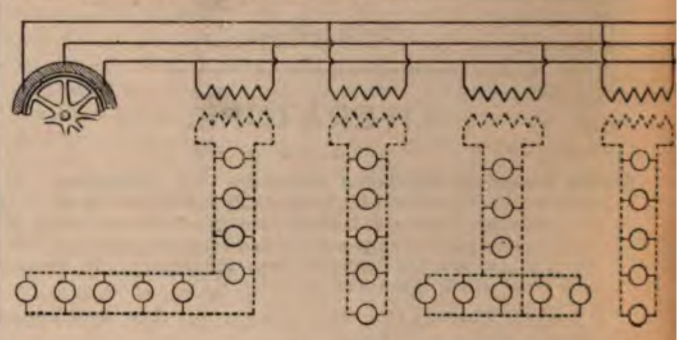


FIG. 15.

Since the supply mains have to carry currents of very high potential, it is advisable that their insulation from one another, and from earth, be as high as possible, and consequently, where feasible, it is better to put them above ground. Such, however, is not always possible, as local authorities in some places, notably in Paris, will not permit this, and the question of proper insulation then becomes a serious matter. Another question also involved, and one which makes an important feature to be considered, is the tendency that alternating currents have to break down the dielectric of their conductors, especially when such conductors are in close proximity to the earth; and retardation of the current under these conditions also comes into the question to an extent not occurring with aerial lines. I know of but one supply station working on this system with high-potential transformers in parallel where the supply mains are placed under ground, and this is at Tours, in France. M. Naze, the engineer who

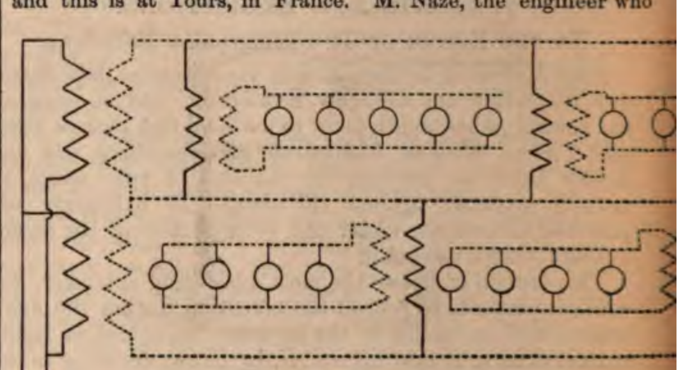


FIG. 16.

carried out the work, however, tells me that he has experienced but little difficulty from these sources, although the installation has been at work now for over two years. The mains, both supply and distributing, are laid in earthenware troughs under the pavement in the streets. Fig. 17 shows in cross section an arrangement I would propose, which resembles in many respects that adopted at Tours, and which I have reason to believe would be found efficacious. The troughs (rectangular in form) would be about 4ft. long and 15in. deep, having spigot and socket joints at the ends, after the manner of ordinary socket pipes, so that complete continuity could be maintained. Transverse pieces of wood, resting upon longitudinal projections inside and on the sides of the troughs, would serve to support the mains, both supply and distributing; and a cover, recessed along each edge of its bottom as shown, would make the conduit thus formed fairly water-tight. This cover would also have lapped ends. Any leakage that might occur into the trough would fall to the

* Paper read at the Society of Telegraph-Engineers and Electricians, *February 9th, 1888.*

bottom, and an arrangement for drain-off holes would be provided, so as to keep the conduit clear from accumulated water. The transverse wood joists in themselves offer a fair amount of insulation, and if paraffined would be but little hygroscopic. The mains would be led away, where required, into the houses through stuffing glands in the sides of the troughs. Repairs and alterations to connections could easily be effected in a conduit of this description. The question involved is, in my opinion, of considerable importance, as sooner or later conductors for lighting purposes will have to go underground in most of our European cities.

Where the supply mains are erected overhead, they may be either supported on poles fixed to the roofs of buildings, as has been done in the supply system from the Grosvenor Gallery, or they may be carried on poles which are placed along the roadways or streets, as is usually the case in the United States.

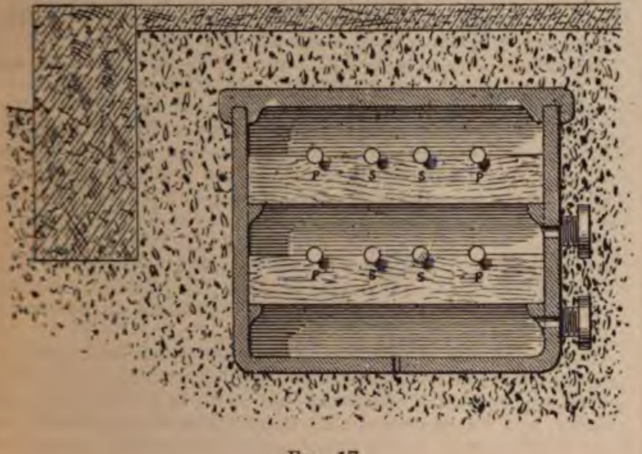


Fig. 17.

Fig. 18 shows the top of the poles that are used by the Westinghouse Electric Light Company, of Pittsburgh, and employed in most of their installations. It will be observed that the transformer itself is supported and carried by the pole in an arrangement devised by Mr. Stanley, of that company, which is very complete and effective.

Generally speaking, where the supply mains are somewhat heavy, it is, in my opinion, advisable to suspend them on bearers, having a factor of safety of at least ten times that of the strain to which they would normally be subjected. The mains would be suspended from these bearers by insulating rings encircling the main, and attached by wire to the bearer at regular distances

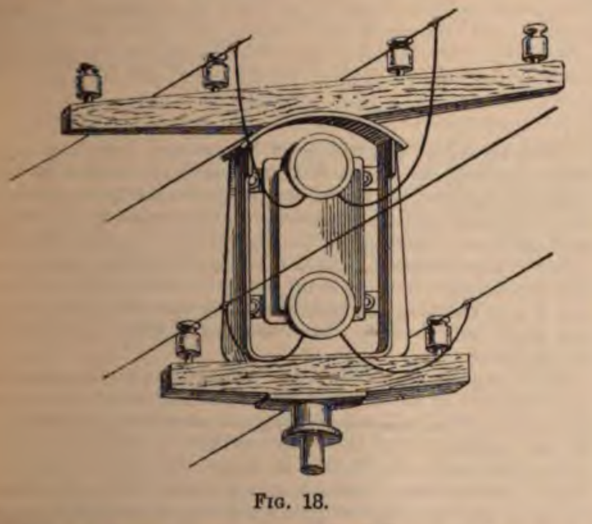


Fig. 18.

of about a yard. The bearers should themselves be of stranded copper wire in cities like this, where free sulphur is so prevalent in the air; and this has lately been done in London, the old steel bearers being replaced by the new copper wire ones. Possibly phosphor-bronze would be very suitable for purposes of this nature, as it possesses great tensile strength. Both bearers and mains should be carried on insulators, which should have the form of double shackles, as this enables branches to be taken off without disturbing the line when up, and also affords greater strength and solidity. When the Grosvenor overhead circuit was first put up for use with series transformers, Mr. Brougham and I employed cast-iron boxes on the poles, into which the ends of the supply mains were brought and sweated into insulated brass sockets, as shown in Fig. 19; but although great care was taken to close all the joints carefully, moisture to a considerable amount collected inside, and they were ultimately abandoned. In less humid climates, however, they might prove adaptable; and if the transformer cases shown in Fig. 18 can be kept water-tight, certainly these also should be so. The arrangement of connection in these "junction boxes" explains itself.

One point of interest in connection with the use of bearers should be noted, which is that since the bearers run parallel throughout their length with the supply mains, they become inductively charged with electricity. Now, if the ends of the bearers be left open, no current can flow through them; and similarly with the case of a series-transformer with the secondary ends open: a counter electromotive force is opposed to that existent in the adjacent main, which, to a greater or less degree, is retarded thereby. Hence, it appears advisable to "close the

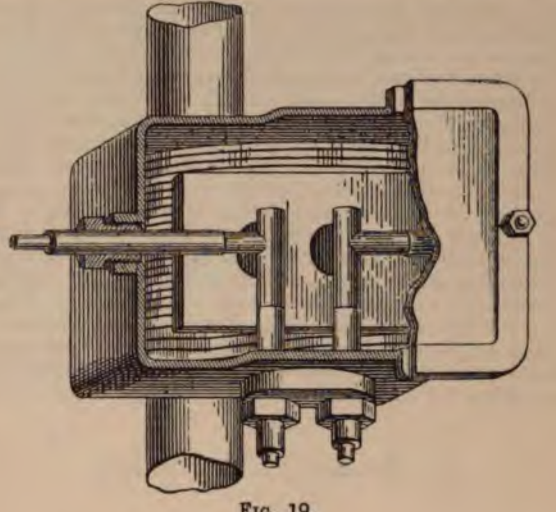


Fig. 19.

bearer circuit," if such a term may be employed, and to clos it by means of lightning arresters to earth at each end. This is not a "metallic" closing of the circuit, but somehow it appears to produce the desired effect, and also at the same time affords a protection to the line. I am speaking here of lines of several miles in length; of course on shorter circuits the effect is not considerable.

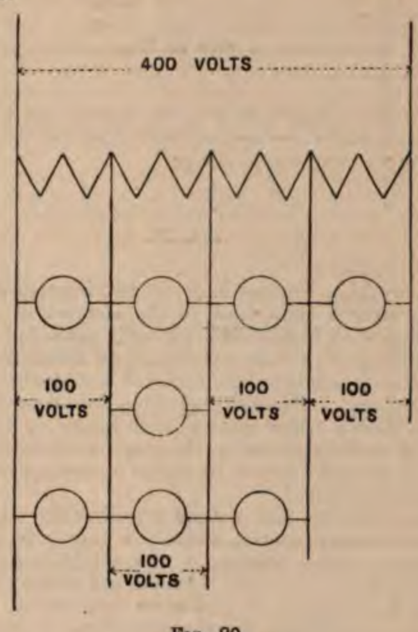


Fig. 20.

The distance between the two supply mains should be not less than 12in.; and as, practically speaking, they are at a given moment of opposite polarity, the effect of the current flowing through them is, upon telephonic circuits even, almost nil. Possibly some here may remember that when the Grosvenor supply station was started, almost two and a half years ago, havoc was played with the United Telephone Company's wires in that part of London, and to a greater or less degree the effect was felt throughout their whole system. We were then working transformers in series, and consequently had but one wire; and the annoyance grew to such an extent that the company commissioned Dr. Hopkinson to meet Mr. Brougham and myself and study the matter, to find a remedy, if possible, for the trouble they suffered. After several experiments, we found that it was only necessary to run a return wire, and the difficulty

would cease, which was at once done. I mention this fact, as it may be of interest now that telephone exchanges exist in almost every large town, and the proprietors might raise difficulties in the way of electric light enterprises based on the employment of alternating currents, from the fear that their systems of telephonic communication might be seriously affected and prejudiced.

One peculiar feature connected with electric lighting systems employing alternating currents I wish to bring to your notice, as it may be of interest as well as instructive. It relates to the use of lead-covered cables as conductors. In many ways these cables offer advantages as regards mechanical protection which are not possessed by others, but the mere fact of the existence of this metal covering brings into play difficulties which might not have been supposed likely to occur.

An installation has been erected in Aschersleben, in Germany, by the National Company, owners of the Gaulard-Gibbs patents, which has for a long time worked successfully. When it was first started, however, lead-covered wires were employed as supply and distributing mains; and, though great care was exercised in laying them down, it was found that no insulation could be maintained, as they were always breaking down and becoming useless. The reason was due to this interesting fact—that the alternating current flowing through the cable set up an induced current in the lead covering, which at places along its length used to spark across to the supports—at first very slightly, but sooner or later to a considerable extent; the lead covering would then at these places become melted, and so exposing and injuring the dielectric completely break down the insulation. The lead-covered cables have since been discarded, and ordinary conductors employed. It must be noted, however, that under any circumstances good insulation is difficult to maintain in this installation, for Aschersleben being the site of chemical and salt

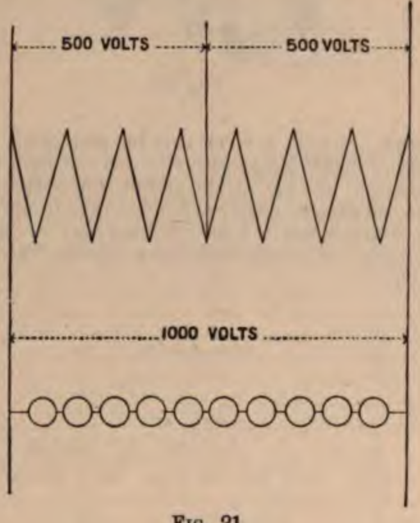


FIG. 21.

works, everything becomes more or less impregnated with that substance after a time, and so the chances of a breakdown through imperfect insulation are greatly enhanced.

In designing an extensive electric light installation in a town, one of the main points to be considered is where the transformers are to be placed. Generally speaking, two courses are open—either to place a transformer in each house, or to locate transformers at various places in the town with distributing mains from them along the streets, overhead or underground, to supply the houses as required.

In many cases the first method is preferable, where, as at the Grosvenor Gallery central station, a supply is given to but a comparatively small number of the neighbouring houses, and customers can be, as it were, selected, and where the installation is in the first instance erected as an experiment. Under these and similar conditions, transformers placed in each house to be lighted is perhaps the best method of proceeding; but in all installations based on a thoroughly practical design distributing stations must be employed as a means of obtaining a more perfect supply and control over the system. The transformers are thus placed out of the reach of all but the company's servants, and cannot be tampered with, whereby accidents are more easily avoidable. The position of these transformers depends, of course, upon the amount of lighting to be done in their neighbourhood, and I prefer to so locate them that the furthest house supplied is not more than 120 yards from the nearest transformer. This allows but little fall of potential in the distributing mains from each instrument, and, as Professor Forbes showed in his Cantor Lectures before the Society of Arts, is about the most economical distance at which lights can be worked.

The Westinghouse Electric Company, in their installations, *couple all* their secondaries or distributing mains together *throughout the area lighted*, thus equalising the potential over the district, and also in the case of a breakdown of one transformer preventing the extinction of the lights which were fed by that particular instrument. This system is practically a "network" system of distributing mains (Fig. 14), and involves a large amount of calculation in proportioning the sizes of the conductors, especially of those which join one group with another, if an installation to be thus carried out be properly and carefully gone into. I believe in practice, however, our American friends do not trouble themselves much with regard to this matter, but continue on with the cables used in the neighbouring districts.

Transformers, when thus placed to supply districts, may be located in cellars, in little street boxes under lock and key, or may be placed on the poles as before described.

I have here a plan of the mains, supply and distributing, worked out for the town of Port of Spain, Trinidad, which installation will be an interesting one, from the extent of the area lighted. I have not adopted the network system in this instance at present, on account of the scattered position of the houses; but later on probably all the secondaries will be coupled up, when the lighting in the town becomes general.

All transformers should be protected by fuses or cut-outs, and one of these should be placed on each wire leading from the supply mains to the instrument. On account of the high potential employed, I prefer to use that kind which consists of a thin wire of a length not less than six inches, having a weight, such as a lump of plaster of Paris, in the middle, in order to break the circuit quickly when the fuse goes. It is astonishing the length of arc that can be maintained by a current of 2,400 volts when the circuit is broken, and therefore I think these fuses should be long and well weighted. The secondaries should also have fuses attached between the poles of the transformers and the distributing mains, though these may be of the ordinary type in use with low potentials.

A switch should be provided to open the circuit leading to the primary poles of the transformer; and all switches which thus control high potential circuits should be made to snap open very quickly, and be so constructed as to make it impossible that they should remain in any other position than hard on or hard off.

FIG. 22.

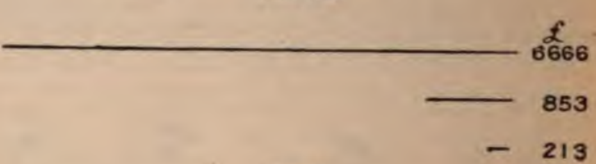


FIG. 23

With regard to the wiring of houses and buildings supplied with electricity by means of transformers, the rules in force in ordinary installations are of course applicable throughout; but I would remark that on no account should existing gas fittings be utilised in any building, as the chances of a breakdown are very considerably increased. At the Grosvenor Gallery supply station this was brought forcibly to my notice on more than one occasion, and I may mention one instance which occurred some two years ago which will show you what risk is run when gas fittings are so employed.

In a large shop in New Bond-street some of the gas fittings were utilised by the contractor for the attachment of glow lamps, and all went well till one evening a short-circuit occurred on one of the gasoliers, and the shop was left in darkness. They at once sent over to the Gallery to know what to do; and shortly after a servant came round from a consumer's house in Bruton-street to say that all the lights were out, and in a few moments other messengers came, informing us of further failures of the light elsewhere on the supply circuit.

We found that the current had gone to earth at the shop in Bond-street, destroying the insulation between the primary and secondary of the transformer, and thus putting the primary current to earth. A weak spot existing in the lamp wires at the other house immediately developed itself in the same manner, again breaking down the insulation and putting the primary current to earth at that place as well. The result was that all those consumers situated between the two breakdowns were left in darkness, as the current traversed the earth, or rather the gas pipes, between the two places where the breakdowns occurred, instead of going through the line. When the two faulty transformers had been switched out of circuit, the current again flowed through the line and the intervening transformers, thus restoring the supply.

I would remark that at that time the transformers were in series, but I can quite conceive a similar state of affairs occurring on a parallel supply system.

There appears no real necessity ever to use gas fittings; but if it be a question of expense, let them be entirely disconnected from the gas pipes, and then of course they may be used as any ordinary electric light fittings.

Every house, when supplied from distributing mains, should have a main switch to control the supply within the building, and where meters are employed this should be placed between the meter and the main. Preferably these should be "double-pole" switches. Fusible cut-outs ought also to be employed in the house mains, and these should be proportioned to suit the maximum current supplied to the house.

In the States, the Westinghouse Electric Company employ almost invariably glow lamps of 50 volts, as they find that these last longer and are stronger than the ordinary 100-volt lamps.

I have now tried to lay before you and explain the general principles of electrical distribution by means of transformers, without entering into theory or into other scientific and theoretical details which the subject involves, since such matter requires independent discussion. My object has been to give you a general outline of the principles involved, and their practical application, as well as some of the experiences I have gained in the matter since I first took it up with Messrs. Gaulard and Gibbs in 1883.

Before concluding, however, I would like to draw your attention to the results of some experiments made by Mr. William Stanley, jun., of the Westinghouse Electric Company, and which were briefly described in the American journal the *Electrical Engineer* of September, 1887. I have had no experience myself of what he describes, and can only refer to him as my authority.

Figs. 20 and 21 will show the theory of his apparatus, which, by the way, he calls an "auto-converter," as it consists of but *one* coil only, and no distinct primary and secondary circuits.

Fig. 21 shows one method of raising the potential by means of this "auto-converter." A B is a converter consisting of a single coil, and as it is evident that one half of the coil acts to the other half as the primary of an induction coil to its secondary, the potential between A B is constant, and double that of A C. A current of, say, 500 volts could be applied between the points A C of the coil, and if A C were to equal C B, a current having a potential double that of A C could be taken off between A B—in this case 1,000 volts.

Fig. 20 shows theoretically an auto-converter reducing the potential. A B is a coil of one circuit only, and is divided into four equal divisions, viz., A E, E D, D C, and C B. If the potential between A and B be 400 volts, since the subdivisions are equal, they will each have a fourth part of the initial potential, and therefore may be employed individually to supply similar receivers as shown. If the resistance between adjacent divisions be equal, the arrangement becomes a series multiple coupling, and the coil A B has no work to do, consequently losing nothing by conversion. If, however, the resistance between any two adjacent divisions is varied—say, for instance, increased—then that portion of the coil A B included between those divisions acts as a primary to the rest of the coil, and the potential difference between all the branches remains constant.

From this it appears that the coil acts only to supply an induced current to such resistances in any division as are less than the resistance of the neighbouring branches, and therefore the loss due to conversion is simply that due to the conversion of the current flowing through the algebraic sum of the resistances of the separate branches or divisions. This form of converter possesses the same merit in potential distribution that the three-wire system does in the direct system.

I am not aware whether these auto-converters have been used in practice, and I feel considerable doubt as to what the result might be. One difficulty which appears likely to stand in the way of success with such a system of conversion is that as the high-potential mains are directly connected to the lamp or other receiver circuits, not only are such receivers placed at an equal potential above the earth with the main, but any failure or breakdown in the insulation of the receiver circuits would result in a tendency to destroy the whole insulation of the system, not only at the particular instrument directly connected to the fault, but along the whole line. When breakdowns occur in the insulation between the secondary of an ordinary two-circuit transformer and the earth, there is, at any rate, the insulation between the secondary and primary existing as a safeguard against putting the primary also to earth.

I will now conclude by referring you to Figs. 22 and 23, which will graphically show you what the development of electrical distribution by transformers or secondary generators has done towards lessening the cost of a general electric supply; although, instead of "lessening the cost," we should, I think, say "rendering electric supply *possible*." The figures are taken from Dr. F. L. Pope's article to the American journal before mentioned. In Fig. 22, A B and C are drawn double the natural size, but show proportionally the area of cross section of the total mass of copper necessary to supply 5,000 16-c.p. glow lamps, situated at a mean distance of 4,000 feet from the dynamo. A refers to the three-wire system, working at a potential of 200 volts, with a fall of potential or loss of energy in the feeders of 10 per cent.—the usual conditions under which this system is worked. B shows the size of conductor required for the same work in an installation based on the transformer system, allowing 2·5 per cent. loss in the supply mains—only one-fourth as much as in the direct system. If this loss were increased and made equal to that in the direct system, viz., 10 per cent., the size of conductor would be that shown at C.

Fig. 23 shows what the relative cost would be between each of the three conditions just named. This speaks for itself.

I believe you will agree with me that the introduction of transformers as applied to electric distribution is the greatest step forward that has been made since the great Electrical Exhibition in Paris of 1881.

I append a list of towns in which, as far as I can ascertain up to the present moment, alternating current and transformer supply stations exist, giving the approximate number of lights supplied; but it must of necessity be incomplete, through causes which those who have also tried to collect statistics can appreciate.

CENTRAL ELECTRIC LIGHT STATIONS ON THE TRANSFORMER SYSTEM.

Approximate Equivalent Output in 16-c.p. Lamps.

ENGLAND.

London (Grosvenor Gallery)	about 8,700	...	Ferranti.
Brighton		...	Lowrie-Hall.
Eastbourne		...	,,

SCOTLAND.

Cathcart	about 500	...	Rankin-Kennedy.
Glasgow	600	...	,,

FRANCE.

Tours	about 2,000	...	Gaulard-Gibbs.

GERMANY.

Aschersleben	about 1,000	...	Gaulard-Gibbs.

ITALY.

Tivoli	about 450	...	Gaulard-Gibbs.

UNITED STATES.

	Westinghouse.		Westinghouse.
Austin, Texas	1,300	Chattanooga, Tenn.	1,650
Beaver Dam, Wis.	1,300	Pittsburgh, Pa. (S.S.)	—
Galveston, Tex	1,300	Alleghany, Pa.	—
Denver, Col.	7,000	Philadelphia, Pa.	2,000
Steubenville, Ohio	1,000	Plainfield, N.J.	1,300
Ouray, Col.	300	Schenectady, N.Y.	1,300
Tyrone, Pa.	1,300	Philadelphia, Pa. (S. & C.)	1,300
Charlestown W., Va.	650	Carbondale, Pa.	1,950
Morristown, N.J.	650	Lincoln, Neb.	2,000
Parkersburg W., Va.	2,000	Flint, Mich.	650
Trenton, N.J.	5,200	New London, Ct.	2,600
New Orleans, La.	5,200	Duluth, Minn.	1,300
Tampa, Fla.	600	Bemington, Vt.	650
Springfield, Mass.	2,000	St. Cloud, Minn.	650
Pittsburgh, Pa.	12,000	Fort Scott, Kans.	650
,, ,, (East End)	2,000	Hillsdale, Mich.	400
Buffalo, N.Y.	2,000	San Antonio, Tex.	650
Greensburg, Pa.	1,300	Springfield, O.	2,000
Torrington, Ct.	1,300	Cheboygan, Mich.	650
Littleton, N.H.	650	York, Pa.	650
Phila, Pa.	6,200	Oneonta, N.Y.	650
Stapleton, Staten Island	2,000	Nashville, Tenn.	1,300
Savannah, Ga.	1,300	Peekskill, N.Y.	650
Portland, Me.	650	Cedar Rapids, I.A.	1,300
Easton, Md.	650	Bath, Me.	650
Colorado Springs, Col.	1,300	Port Huron, Mich.	650
Hartford, Ct.	2,000	Stillwater, Minn.	650
St. Louis, Mo.	5,200	Marion, Kans.	650
Minneapolis, Min.	6,500	Junction City, Kans.	650
Richmond, Va.	1,300	Buffalo, Wyo. Terr.	400
Pittsfield, Mass.	1,300	Newton, Kans	650
Sheffield, Ala.	650	Hoboken, N.J.	1,300
Cornwall, Ont., Canada	650	Altoona, Pa.	650
Wheeling W., Va.	2,000	Havoac Tunnel	1,300

AMENDMENT TO ACT, 1882.

LORD THURLOW'S BILL INTRODUCED INTO THE HOUSE OF LORDS.

Act to amend the Electric Lighting Act, 1882.

Be it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same as follows:—

1. Notwithstanding anything in the Electric Lighting Act, 1882, no Provisional Order authorising the supply of electricity by any undertakers within the district of any local authority shall be granted by the Board of Trade except with the consent of such local authority, unless the Board of Trade, in any case in which the consent of such local authority is refused, are of opinion that, having regard to all the circumstances of the case, such consent ought to be dispensed with,

and in such case they shall make a special report, stating the grounds upon which they have dispensed with such consent.

2. Section 27 of the Electric Lighting Act, 1882, is hereby repealed, and in lieu thereof the following provisions shall have effect; that is to say,

Where any undertakers are authorised by a provisional order or special Act to supply electricity within any area, any local authority within whose jurisdiction such area, or any part thereof, is situated, may, within six months after the expiration of a period of forty-two years, or such shorter period as is specified in that behalf in the provisional order, or in the special Act, from the date of the passing of the Act confirming such provisional order, or of such special Act; and within six months after the expiration of every subsequent period of ten years, or such shorter period as is specified in that behalf in the provisional order, or in the special Act, by notice in writing require such undertakers to sell, and thereupon such undertakers shall sell to them their undertaking, or so much of the same as is within such jurisdiction, upon terms of paying the then market value of the goodwill of the business and of all lands, buildings, works, materials, and plant of such undertakers suitable to and used by them for the purposes of their undertaking within such jurisdiction, such value to be in case of difference determined by arbitration: Provided that the value of such goodwill, lands, buildings, works, materials, and plant shall be deemed to be their fair market value at the time of the purchase, due regard being had to the nature and then condition of such buildings, works, materials, and plant, and to the state of repair thereof, and the suitability of the same to the purposes of the undertaking, and, where a part only of the undertaking is purchased, to any loss occasioned by severance, but without any addition in respect of compulsory purchase. The Board of Trade may determine any other questions which may arise in relation to such purchase, and may fix the date from which such purchase is to take effect, and from and after the date so fixed, or such other date as may be agreed upon between the parties, all goodwill lands, buildings, works, materials, and plant so purchased as aforesaid shall vest in the local authority which has made the purchase, freed from any debts, mortgages, or similar obligations of such undertakers or attaching to the undertaking, and the powers of such undertakers in relation to the supply of electricity under this Act or such provisional order or special Act as aforesaid within such area or part thereof as aforesaid shall absolutely cease and determine, and shall vest in the local authority aforesaid.

3. Notwithstanding anything in the last preceding section contained, the Board of Trade may by any Provisional order to be made by them under that Act, if they think fit, vary the terms upon which any local authority may require the undertakers to sell, and upon which the undertakers shall be required to sell to such local authority their undertaking, or so much of the same as is within the jurisdiction of such local authority under the said section, in such manner as may have been agreed upon between such local authority and the undertakers.

4. (1.) Where in any case any electric line or other work may have been laid down or erected in, over, along, across, or under, any street, for the purpose of supplying electricity, or may have been laid down or erected in any other position for such purpose in such a manner as not to be entirely enclosed within any building or buildings, or where any electric line or work so laid down or erected may be used for such purpose otherwise than under and subject to the provisions of a license, order, or special Act, the Board of Trade, if they think fit, may, by notice in writing under the hand of one of the secretaries or assistant secretaries of the Board of Trade, to be served upon the body or person owning or using or entitled to use such electric line or work, require that such electric line or work shall be continued and used only in accordance with such conditions and subject to such regulations for the protection of the public safety and of the electric lines and works of the Postmaster-General as the Board of Trade may by or in pursuance of such notice prescribe, and in case of non-compliance with the said regulations then the Board of Trade may require such body or person to remove such electric line or work. Provided that nothing in this sub-section shall apply to any electric line or work laid down or erected by any body or person for the supply of electricity generated upon any premises occupied by such body or person to any other part of such premises.

(2) Where in any case any electric line or work is used for the supply of electricity in such a manner as to injuriously affect any telegraph line of the Postmaster-General, or to affect the telegraphic communication through any such line, the Postmaster-General may, by notice to be served upon the body or person owning or using or entitled to use such electric line or work, require that such supply be continued only in accordance with such conditions and regulations for the protection of the telegraph lines of the Postmaster-General and the telegraphic communication through the same as he may by or in pursuance of such notice prescribe, and in default of compliance with such conditions and regulations the Postmaster-General may require that the supply of electricity through such electric line or work shall be forthwith discontinued; provided that nothing in this sub-section shall apply to the supply of electricity through any electric line or work laid down or erected under and subject to the provisions of any license, order, or special Act, or which may be used in accordance with any conditions or regulations prescribed by the Board of Trade by or in pursuance of any notice given by them under this section.

(3.) If anybody or person fails to comply with the requirements of any notice which may be served upon them or him under this section, such body or person shall be liable to a penalty not exceeding twenty pounds for every such offence, to be recovered summarily, and any *court* of summary jurisdiction, on complaint made, may make an *order directing and authorising the* removal of any electric line or work specified in such notice by such person and upon such terms as they may think fit.

(4.) Any noticed authorised to be served under this section upon any body or person may be served by the same being addressed to such body or person, and being left at or transmitted through the post to any office of such body or the usual or last known place of abode of such person, and any notice so served by post shall be deemed to have been served at the time when the letter containing the notice would be delivered in the usual course of post, and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and put into the post.

(5.) In this section terms and expressions to which by the Electric Lighting Act, 1882, meanings are assigned shall have the same respective meanings, provided that the term "street" shall include any square, court, or alley, highway, lane, road, thoroughfare, or public passage or place whatever, and the expression "telegraphic line" shall have the meaning assigned to it by the Telegraph Act, 1878.

(6.) Nothing in this section shall apply to any electric line or work of the Postmaster-General, or to any other electric line or work used or to be used solely for telegraphic or telephonic purposes.

5. This Act may be cited as the Electric Lighting Act, 1888; and the Electric Lighting Act, 1882, and this Act shall be read and construed together as one Act, and may be cited together for all purposes as the Electric Lighting Acts, 1882 and 1887.

ELECTRIC LIGHTING IN THE CITY.

At a meeting of the City Commission of Sewers, held on Tuesday, at which Mr. W. H. Pannell presided, the Streets Committee brought up a report submitting for adoption an amended arrangement with the Anglo-American Brush Electric Light Corporation for lighting a district of the city by means of electricity. The district to be lighted commenced from the front of the Royal Exchange, and comprised so much of the city as lies between the Poultry, Cheapside, St. Paul's, Ludgate-hill, and Fleet-street on the north, and Queen Victoria-street and the Embankment on the south.

Mr. J. C. Bell, in moving the adoption of the report, referred to the previous connection of the Commission with experiments in electric lighting in the city In 1878 they tried the Jablochkoff system, at an expense of $7\frac{1}{2}$ times the cost of gas, but, as far as they could judge, it failed. In 1881-82 they entered into contracts with three companies for experimentally lighting the city at the same time, to test which was the better system. The Brush Company charged for works, installation, and lighting in the district allotted them £1,410, or twice the cost of the gas there, but the light gave 15 times more illuminating power. The Lontin system cost £2,930, or four times the cost of gas, the illuminating power being $14\frac{1}{2}$ times greater; and the Siemens system cost £3,720, or $3\frac{3}{4}$ times the cost of the gas in the district allotted them, the illuminating power being $13\frac{1}{2}$ times greater. They afterwards entered into a contract with the Edison Company for lighting a part of the city with incandescent lights. None of these systems or experiments gave satisfaction. The terms of the present proposed contract with the Anglo-American Brush Company were double the price of gas in the same area—viz., £4,394 instead of £2,200—but they would get 32 times the amount of light. It was contemplated to use 196 arc lamps of 2,000 candle-power each, at a cost of £26 per annum each. The committee had selected the most frequented parts of the City for the experiment, but if it proved a success, there would be no difficulty in extending it throughout the City. He believed the contract was not only a fair one, but virtually a one-sided one in favour of the public. They had had complaints from many quarters of the insufficiency of the lighting in the City, but any increase in the number of gas lamps would be very expensive. Electric lighting would not only afford a greatly better light, but would minimise the risk of fire and tend to the protection of property. The cost would necessitate an increase of one-eighth of a penny in the pound on the rateable value of the City, of which about one-fifth of the whole area would be lighted by electricity. To those who had any experience of the atmosphere of the large establishments of the City, where hundreds of workpeople were employed—such as the printing offices—the advantage to health by the introduction of the electric light would be patent. While it was proposed to make a contract for a term of seven years, any failure of the Company to observe its provisions would not only bring about its immediate cancelment and the forfeiture of the deposit of £1,000, but would inflict on the Company the loss of their monopoly of private lighting, so that in their own interest the Company would take care to have no failure. The whole of the installation was to be finished by October, 1889, but they hoped to have the City lighted street by street as the work progressed. The Company would have, as far as the Commission could grant it, a monopoly of private electric lighting in the district, but they could not compel the inhabitants to use it, and it was, therefore, to their interests to make the charges as low as possible in order to secure orders and to compete with the gas supply. The same monopoly of lighting was now given to one gas company, with the result that the cost of public street lighting was decreased. In the present case it was estimated that each arc lamp in the streets would cost £40 per annum to the Company, who would, therefore, lose £14 on each lamp; but they would bear this loss for the sake of the monopoly of private lighting. If the experiment proved successful they might go to other companies and get better terms, and if it were a failure they could fall back upon the gas, besides making the company pay for the failure. It had been suggested that the Commission might undertake the work more economically and just as efficiently themselves, or, at all events, that they should have a right of pre-emption of the shares of the Company, but as electric lighting was still in its infancy, he thought that at this period they had better let other people who understood

the work do it. He contended that arc lighting was the proper mode of illuminating a city such as London, and observed that the contract contemplated the provision of shadowless lamps, and of glow lamps in the smaller streets. He believed that if the work was carried out as proposed the Commission would be entitled to the thanks of the community. At all events, they would be likely to bring the gas companies to their bearings. Even that small agitation had had the effect of reducing the price of gas by 6d. per 1,000, and he hoped that sooner or later the gigantic gas monopoly would be broken down. For these reasons he urged the Commission to adopt the report.

Mr. C. T. Harris, as an amendment, moved that the report should be referred back for further consideration. He argued that the present lighting of the City, as far as all practical purposes were concerned, was perfectly sufficient, and that anything further would be merely a luxury, for which the ratepayers should not be called upon to pay an increased tax. He objected to the report on four grounds—viz., because arc lighting was unsuitable for the purpose; because the illuminating power could not be adequately estimated, and was, therefore, enormously exaggerated; because the cost was prohibitory, and because he considered the terms of the contract open to grave criticisim in the interests of the public. On these grounds he begged the Court to give the matter further consideration.

Mr. J. E. Sly observed that four or five years ago a great deal of money was spent by the Commission in experiments with the electric light. It was hardly for the Commission to contemplate lighting one portion of the City at the expense of the other. They had shown their desire for the light by the large sum of money they had spent in experiments. If they contemplated adopting the electric light it ought to be for the whole City. The Maxim-Weston Electric Light Company would supply the electric light to the whole City at £15,000 for the first cost fitting, &c., and £3,875 a year for maintaining the light—800 lamps of 450 candle-power each being supplied. This would pay itself in two years. He asked them to reconsider the matter, so as to get it done in the cheapest way they could, and not to have a seven years' monopoly.

Mr. Bridgman referred to the insufficient manner in which the City was lighted as compared with the Holborn district, and observed that he did not know a more dismal place than the neighbourhood of St. Paul's at night. The electric light had been adopted in New York, Brooklyn, Paris, Vienna, and some towns in England.

Mr. Morton said he was strongly in favour of getting the electric light, but they did not want to be entrapped.

Mr. J. V. Moore supported the amendment. He referred to the improvements which had taken place in gas lighting, and observed that gas was becoming a formidable rival to the electric light. A new lamp had been brought over from Berlin which gave a wonderful light at a consumption of only twelve feet of gas per hour. The Court could not, consistently with its duty, agree to the report, and it ought to be sent back for further consideration.

Mr. L. H. Phillips and **Mr. G. Shaw** also supported the amendment, while **Mr. Deputy Scott** warmly advocated the adoption of the report.

After some further discussion the amendment was declared to be carried on a show of hands. A division was demanded, with the result that the amendment was carried by 36 to 17. The report was accordingly referred back for reconsideration.

PROVISIONAL PATENTS, 1888.

FEBRUARY 10.

2002. **A new electrical tool.** Thomas Thorp, Whitefield, Lancashire.

FEBRUARY 11.

2073. **An improved electric alarm apparatus.** Armand C. Iwanowski, 45, Southampton-buildings, London.

2125. **An improved method of constructing and regulating arc lamps.** Walter Rowbotham, 39, Lever-street, Manchester.

2130. **Improvements relating to electric telegraphs.** Alexander Muirhead, 45, Southampton-buildings, London.

FEBRUARY 13.

2178. **Improvements in plates for secondary batteries.** Robert Nelson Boyd, 18, Buckingham-street, Strand, London.

2179. **Electric lights.** Marshall Wheeler, 18, Buckingham-street, Strand, London.

FEBRUARY 14.

2235. **Improvements in or applicable to electric conductors.** John Annan Bryce, Norfolk House, Norfolk-street, London.

2239. **An improved electrical door and window contact.** John Thomas Mayfield and Joseph Torr Todman, 21, Finsbury-pavement.

2246. **Improvements relating to dynamo-electric machines.** Henry Harris Lake, 45, Southampton-buildings, London. (Rudolf Eickenmeyer, United States.)—(Complete specification.)

2250. **Improvements in printing telegraphs.** Jacob Hays Linville, 24, Southampton-buildings, London, W.C.—(Complete specification.)

2251. **Improvements in switches for electric circuits.** Alfred Graham, 47, Lincoln's Inn-fields, London.

2259. **Improvements in thermo-electric and furnace batteries.** Hugo Mestern, 97, Newgate-street, E.C.

FEBRUARY 15.

2314. **Improvements in electrical safety fuses.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London, W.C.

2304. **Improvements in fireproof "batten" lights for electrically lighting the stages of theatres and other similar buildings.** Samuel Sudworth and Ernest Lower Berry, 23, Andalus-road, Clapham, S.W.

2308. **Improvements relating to dynamo electric machines.** Carl Coerper, 45, Southampton-buildings, London.—(Complete specification.)

2313. **Improvements in dynamo-electrical machines and apparatus used in connection therewith.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London, W.C.

2315. **Improvements in electrical mains.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London, W.C.

2316. **Improvements in dynamo-electrical machines and apparatus used in connection therewith.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London, W.C.

FEBRUARY 16.

2368. **An improved method of manufacturing woven plates for secondary batteries.** Mark Bailey and John Warner, 21, Finsbury-pavement, London, E.C.

2369. **An improved system of electrical or other signalling between signal cabin and driver and guard in charge of railway trains in motion or otherwise, and apparatus therefor.** John Orme, 21, Finsbury-pavement, London, E.C.

COMPLETE SPECIFICATIONS ACCEPTED.

FEBRUARY 18, 1887.

2563. **Improvements in electrical primers.** George Stuart, Elswick Works, Newcastle-on-Tyne.

FEBRUARY 19, 1887.

2598. **Improvements in electric gas lighters.** Thomas Peter Hewitt, 6, Lord-street, Liverpool.

APRIL 5, 1887.

5096. **Improvements in dynamo-electric machinery.** Gisbert Kapp, 47, Lincoln's Inn-fields, London, W.C.

APRIL 15, 1887.

5485. **Improvements in and connected with internal combustion thermo-dynamic engines.** James Hargreaves, 4, Clayton-square, Liverpool.

JUNE 10, 1887.

8396. **Improvements in electrical-apparatus for preventing corrosion or incrustation of steam boilers and other similar vessels, and for removing the incrustation when once formed.** Augustus John Marquand, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex.

JULY 18, 1887.

10,057. **A process for the extraction of aluminium from its fluorides, by electrolysis.** Ernest de Pass, 68, Fleet-street, London. (Myrthil Bernard and Ernest Bernard, France.)

JAN. 3, 1888.

100. **Improvements in and relating to apparatus for generating electricity.** Henry Harris Lake, 45, Southampton-buildings, London. (William Humans, United States.)

JAN. 14, 1888.

623. **Improvements in thermo-electric elements and piles.** Robert Jacob Gülcher and the Firm of Julius Pintsch, 28, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1887.

563. **Dynamo-electric machine.** H. H. Leigh. (Clerc.) 8d.

701. **Electrical meters.** S. Z. de Ferranti. 8d.

702. **Dynamo electrical machines.** S. Z. de Ferranti. 11d.

717. **Disc dynamo-electric machines, &c.** W. B. Sayers. 8d.

800. **Electric telegraph apparatus.** J. B. Willis. 1s. 3d.

831. **Converting alternating currents into continuous ones.** M. Immisch. 8d.

2390. **Electrolytical treatment of ores for recovering gold silver, &c.** H. Leipmann. 8d.

2517. **Telegraph poles, &c.** D. Wilson. 8d.

2959. **Electric alarms.** H. C. Chocqueel. 8d.

3605. **Simultaneous telegraphy and telephony.** C. Selden. 8d.

3878. **Electric alarm clocks.** H. Boardman. 8d.

3943. **Measuring electric currents.** W. H. Douglas. 8d.

4153. **Mechanical telephone.** T. H. Churton. 6d.

8329. **Electrical signalling apparatus for railways.** W. E. Langdon. 8d.

11,923. **Plates for primary or secondary electric batteries, &c.** C. L. R. E. Menges. 8d.

14,768. **Switches for making and breaking circuits conveying electric currents.** C. M. Dorman and R. A. Smith. 8d.

16,351. **Electric belts.** A. Owen. 8d.

16,376. **Electric arc lamps.** C. B. and R. D. Noble. 8d.

17,157. **Galvanic batteries.** H. H. Lake. (Whitten.) 6d.

1886.

10,477. **Deposition of platinum by electricity.** W. A. Thoms. 6d.

12,833. **Subjecting the person to electric currents.** A. Loiseau and O. Pierrard. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednes-day-
3 Jan.	4%	African Direct 4%	100	98 to 100
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4¼
15 Feb.	10/0	Anglo-American	100	40¼
15 Feb.	20/0	— Pref.	100	66¼x
12 Feb., 85...	5/0	— Def......................	100	14½
29 Dec.........	3/0	Brazilian Submarine.........	10	12
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
15 Feb.	8/0	Cuba	10	12¼x
28 July	10/0	— 10% Pref.	10	18
14 Oct.	1/0	Direct Spanish	9	4¼
18 Oct.	5/0	— 10% Pref.	10	9½
14 Oct.	2/0	Direct United States	20	9⅛
12 Jan.	2/6	Eastern	10	11⅜
12 Jan.	3/0	— 6% Pref.	10	14¾
1 Feb.	5%	— 5%, 1899	100	109
28 Oct.	4%	— 4% Deb. Stock	100	106
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12 5-16
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	105
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	105
12 Jan	5/9	German Union	10	9¼
27 Jan	1/6	Globe Telegraph Trust......	10	5¾
27 Jan	3/0	— 6% Pref.	10	13½
3 Jan	5/0	Great Northern...............	10	13⅞

Dividend.		Name.	Paid.	Price. Wednes-day
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	107
28 July	10/0	India Rubber, G. P. & Tel.	10	18
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5⅝
16 March ...	5%	Maxim Western...............	1	¼
15 May	5%	Oriental Telephone	11	½
14 Oct.	4/0	Reuter's	8	8½
......	...	Swan United	3½	2⅜
15 Feb.	15½%	Submarine	100	145x
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	39⅝
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	13 5-16
......	...	West African..................	10	5
1 Sept.	5%	— 5% Debs.	100	93
29 Dec.........	6/0	West Coast of America ...	10	5½
31 Dec.	8%	— 8% Debs.	100	116
14 Oct.	3/9	Western and Brazilian......	15	9 3-16
14 Oct.	3/9	— Preferred	5½	6½
......	...	— Deferred..................	2½	3¼
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	105
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	10
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 Nov.	7%	West Union of U.S.........	$1,000	125
1 Sept.	6%	— 6% Sterling	100	104

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Jan. ...	£39,878	+ £547
Brazilian Submarine	W. Feb. 10 ...	£3,856	...	Great Northern	M. of Jan. ...	21,400	+ 1,000
Cuba Submarine	M. of Jan. ...	3,300	+ £82	Submarine	None	Published.	
Direct Spanish......................	M. of Jan. ...	1,943	+ 39	West Coast of America	M. of Jan. ...	4,800	...
— United States	None	Published.	...	Western and Brazilian	W. Feb. 10 ...	2,559	...
Eastern..............................	M of Jan. ...	56,164	+ 2,729	West India and Panama	F. Feb. 15......	3,310	+ 298

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Armstrong's Electric Company.—A meeting of this Company is announced to be held at the Company's offices on the 27th inst.

Submarine Cable Company.—A dividend of 15½ per cent. per annum was declared on Tuesday at the half-yearly general meeting of the Submarine Telegraph Company, the Hon. H. R. Brand presiding, at the offices, Throgmorton-avenue.

Western and Brazilian Company.—The traffic receipts of the Western and Brazilian Telegraph Company (Limited) for the week ending February 17, after deducting the fifth of the gross receipts payable to the London Platino Brazilian Telegraph Company, were £3,612.

West India and Panama Company.—The estimated traffic receipts of the West India and Panama Telegraph Company (Limited) for the half-month ended February 15, are £3,310 against £3,012 last year, showing an increase of £298, as compared with the corresponding period of last year.

Channel Cables.—The *Financial News* has been giving some information about these cables, among which it says:—"It is a curious fact that the British Government borrowed the idea of terminating the monopoly of the Submarine Telegraph Company from Belgium. . . . Mynheer Vandenpeereboom, the Minister of Public Works, is well known in Belgium for his independent character. He felt piqued about the 'never-mind-her-policy' of Throgmorton-avenue, and he resolved to show the Submarine Telegraph people that Belgium, albeit small, is not to be trifled with. So one fine day, without telling anybody, the Minister despatched two representatives to the British capital with full powers to treat with the Post Office about the conclusion of an Anglo-Belgian telegraph convention, and the working of the two cables between Ramsgate and Ostend and Dover and La Panne, so soon as the Belgian concession to the Submarine Telegraph Company lapsed—that is to say, in January next. At that time the British Government had not even considered the matter, but Mr. Vandenpeereboom's agents convinced the Post Office that by far the best plan would be to abandon the beautifully-*independent* Submarine Telegraph Company, put an end to its existence, *and annex its property 'for a consideration.'*"

The United Telephone Company.—A meeting of subscribers to the United Telephone Company was held on Monday, at 84, Bishopsgate-street Within, to take into consideration the proposed change by the Company of some of the numbers held by their clients. The change affects for the most part the Leadenhall-street subscribers; consequently, those who were present—some thirty in number—were, almost without exception, representatives of firms in that thoroughfare. Mr. Singer, who, by reason of the interest he has taken in the matter, was voted to the chair, commenced by detailing the steps that led up to the convening of the meeting. The company seemed adverse to the withdrawal of their notice of change, so that his firm had put themselves into communication with other subscribers, their opinions being so unanimously opposed to the change that it was ultimately decided to call the meeting to ascertain what measures should be taken to endeavour to get a redress of grievances. He had received several letters, and all, with one exception, were utterly opposed to the change. Mr. Peall failed to see what right the company had to change a number for which a subscriber had paid in advance. Mr. Fitch (Messrs. Fitch and Co.) said his firm would oppose the change on two grounds—first, that it was unnecessary; and second, that it was illegal. Mr. D. Collin (Messrs. Dunn, Collin and Co.) pointed out that if the change were carried into effect, a man in the same business as himself might be allotted his number, with the result that he would receive the orders intended for him (Mr. Collin). The Chairman said his idea was that they should apply for an injunction to restrain the company from making the proposed change. Mr. C. Haller suggested that a committee should be formed to wait upon the board of directors on the subject. Further discussion ensued, and eventually it was resolved "That this public meeting of telephone subscribers strongly object to the proposed change of numbers on the point of its great inconvenience and expense, besides leading to constant mistakes in orders and inquiries, and hereby appoints a committee to confer with the directors, and report again to the subscribers." A committee, consisting of the chairman, Mr. Fitch, Mr. Haller, Mr. Peale, and Mr. Collin, was appointed, and the proceedings then terminated with a complimentary vote to Mr. Singer.

NOTES.

Electric Lighting in Switzerland.—The electric light is about to be installed in the little town of Martigny.

United Telephone Company.—The Governors of Bridewell and Bethlehem Hospitals have petitioned against this Company's Bill.

Electric Lighting Act.—The Amendment Bill introduced into the House of Lords has its second reading fixed for Monday, March 5.

Eastbourne.—A tradesman has been writing to the local papers about the inferior nature of the gas supply, and says:—"Why does not the Electric Lighting Company wake up and extend facilities for the more general adoption of the new illuminant? I believe scores of gas consumers are ready to transfer their allegiance."

Phœnix Fire Office Rules.—The Twelfth Edition of these rules has followed very closely upon the preceding Edition, the one having been issued in December, 1887, the other in February, 1888. This shows how considerable is the demand for the rules which may be said to regulate all electric light installations in this country.

Projected Electric Lighting of Marlborough House.—His Royal Highness the Prince of Wales has recently decided to have the State apartments and principal rooms in Marlborough House lighted by electricity. The work is in the hands of the officials of the Prince's household, and the current will, it is stated, be supplied by the Grosvenor Gallery Company.

Electric Lighting in Spain.—The central station at Pontevedra will shortly be completed. The installation, carried out by M. Alvar Gonzales, will comprise about 1,500 10 c.-p. incandescence lamps.—The municipality of Valence, who had forbidden the use, within the town, of any boiler above from 4 to 5 h.-p., have removed their interdict in favour of the boilers made, according to the Collet system, by the *Société des Générateurs Inexplosibles.*

The Schanschieff Lamp.—The Princess Christian has accepted from the Schanschieff Syndicate a reading lamp manufactured on the Schanschieff principle. It is the first of its kind that has been made adapted to domestic uses, and Mr. Schanschieff, who presented it, had the honour of explaining its working. The Princess was greatly pleased at its simplicity, and the easy manner with which the light could be regulated from one to ten candle-power or totally extinguished and immediately relighted at will in a second.

Electric Lighting Regulations.—The Society of Electricians, at Vienna, recently nominated a Committee to draw up a set of regulations relative to the distribution of electrical power, which will be laid before the Austrian Parliament to serve as a basis for a new law on this subject. This Committee has just concluded its labours; and its report will be submitted to the members of the Society at their next general meeting, in order that it may be discussed and, if necessary, modified before being presented to Parliament.

The Electric Light in Italy.—According to the *Bulletin des Sociétés d'Electricité*, great activity prevails at the present moment in the Italian military ports—Naples, Castellamare, Livourne, Genoa, and Spezzia. Four thousand supernumerary labourers have been engaged, and are working day and night at the establishment of the electric light. At Cape Porto-Fino, Cape Mele, and at the islands of Sardinia and Maddalena, twelve electric lighthouses are to be constructed. At the Venice arsenal also, they are working day and night in connection with electric lighting and the manufacture of torpedoes.

Long-Distance Telephoning.—A telegram dated Paris, Tuesday, says:—The French are about to accomplish another feat in long-distance telephoning by the establishment of communication between Paris and Marseilles. The line will be subterranean between Paris and Nogent-sur-Marne, whence it will follow the course of the Paris, Lyons, and Mediterranean Railway. The works have been almost completed in all the departments through which the wire will pass. It is only necessary now to cover some short spaces, and it is estimated that everything will be in working order by July. The first wire, which is of bronze, is rather thicker than those of the existing long-distance lines.

Brighton Electric Light Company.—A meeting of the shareholders of the Brighton Electric Light Company was held at the works of the Company last week, and great satisfaction was expressed at the nature of the report for the past fifteen months. The managing director, Mr. Arthur Wright, was congratulated upon the successful manner in which he has conducted the Company's business. There had, it was stated, been a great increase in the consumption of electricity, and the plant had recently been considerably added to in order to still further cope with the business coming before the Company. It was resolved that an expenditure of £3,000 should be made on additional plant.

Cardiff Docks.—We have several times referred to the lighting of the Cardiff Docks, the work of which is being carried out by Messrs. Crompton and Co. The installation has proceeded so far that a number of lamps have been put up, at an elevation of some 25ft. or 30ft., near the pier-head and the principal bridges. These, on being tried last Monday night, were found to work in an eminently satisfactory manner, so much so that electric lighting at the Cardiff Docks may now be looked upon as a permanent thing. It is expected that by the time this reaches the eyes of our readers the lamps will be in constant use, and will be considerably augmented.

Provisional Orders.—The question addressed to Sir M. Hicks-Beach last week elicited the following reply:—Since the passing of the Electric Lighting Act, 59 provisional orders and 5 licenses have been granted to companies, and 15 provisional orders and 2 licenses to local authorities. The Board of Trade are not aware of any cases in which the powers obtained are now being exercised. It is not possible to express an opinion as to the reasons which may have led to this result within the limits of a reply to a question. A Bill to amend the Act has been introduced in another place, on which the views of the Government will be stated and issues discussed.

The Electric Light in Brussels.—M. Aerto, the director of the Brussels gas-works, has been appointed inspector of public lighting for the city, *vice* M. Wibauw, who has been placed in charge of the electric lighting, the electric clocks and the telephones. As our readers are aware, the installations of electric lighting in this town consist at present of the works supplying the *Théâtre de la Monnaie*, the *Grande Place*, and the *Théâtre du Parc;* but the municipal Council has pronounced in favour of a project for the construction of a central electrical station, which

would supply the light to the principal *restaurants, cafés* and public buildings. Negotiations with the *Société Industrielle* are in progress with a view to carry this installation into effect.

Barnet.—At a meeting of the Barnet Local Board on the 21st ult., Mr. Marriott gave notice of motion as follows:—"That the time has now arrived for the Board to take into consideration the lighting of its district either by the electric light or otherwise, taking into account the high price of gas and the bad illumination they get for the money which they pay for the supply of gas to the public lamps." A letter was read from the Pilsen-Joel Electric Lighting Company, asking the Board to grant them permission to carry overhead wires to supply the town with electric light at a given rate, and to give them a monopoly of supply for three years. It was incidentally mentioned that the Company had canvassed the town and obtained large promises of support from intending consumers.

Telephony.—Two new telephone companies have been formed, one in Rosario, with concession for the Argentine Republic and Uruguay, the other one in Cadiz, Spain. This is a double success for Belgium, since these companies, after comparative examination of all telephonic apparatus for subscribers, have adopted the one constructed by Messrs. Mourlon, of Brussels. Everyone knows that this is the very instrument used on the Belgian State telegraphic network, and which gives such wonderful results between Paris and Brussels. It is, perhaps, of all the products of the Belgian industry, the one which has the most extended market, being used not only in America, but also in China, Japan, and even in the Congo, where the network in San Thomé Island has no apparatus but those of this Belgian firm.

Electric Lighting in Belgium.—The syndicate formed by the principal electric lighting firms, with a view to the establishment of central stations for the distribution of the light, have nominated a technical committee, including the names of MM. Bonnevie, Gerard, Goffin, and Julien. This committee has already decided to submit alternative proposals of the two following kinds to the communal administrations of the towns in which it is proposed to adopt electric lighting:—1. A central station working transformers, such as those of Gaulard and Gibbs, Zipernowsky, and Goffin-Hoho. 2. A central station employing the high-potential dynamo machines of Gérard (outside the boundaries of towns) to charge accumulators such as that of M. Julien. The second system, it may be mentioned, has received a successful application in the lighting of the *théâtre de la Monnaie*, under the supervision of M. Gérard.

The Swan Company.—A report of the Swan Company's meeting will be found in another column. It is both interesting and disappointing—the former in that it promises hopes of better things—the latter in that these hopes are deferred. A substantial profit has been made on the year's working, and old losses are now paid off, so that if any profits are made in the future there is no reason why some distribution should not be made to the shareholders. The tendency of the market in the shares of the company has lately been more favourable, and if the business reasonably progresses they ought soon to reach par. The chairman arrogated a considerable amount of business talent to the directors of the company, but if they would listen to the voice of outsiders they would find that buyers are not altogether friendly to the company, and that a considerable change of the *suaviter in modo* must take place during the six years of grace to enable the company to hold its *clientèle*.

The National Gallery.—The suggestion for lighting the National Gallery by electricity, says the *Gas Journal*, is one of those propositions which continually crop up without any real attempt being made to dispose of them. It is very true that the pictures of the National collection, as well as the invaluable contents of the British Museum, are unavailable after dark; and it is equally true, and even more provoking, that many days in London during the winter months are dark throughout. The question is, with regard to pictures, what method of artificial lighting is the best and safest? It would be of little use to art students to light up a picture gallery with either gas or the incandescent electric light, for the simple reason that either would falsify all their colours. The arc light is white enough to paint by; but would the trustees of an invaluable national collection be justified in admitting within their buildings wires carrying the strong currents required for arc lamps? It is doubtful. At all events, they do not display any eagerness to move in this direction; whereat the electricians and their friends emit periodical growls.

The Carriere Accumulator.—M. Carrière constructs a secondary battery with compressed carbon plates, having either a plane or a corrugated, grooved or recessed surface, this surface being coated with a layer, from 1 to 1·5 millimetres in thickness, of a composition made by mixing litharge with dilute sulphuric acid containing $\frac{1}{10}$th of the strong acid. The carbon plates are manufactured by mixing 2 parts of pulverised retort carbon with one part of lampblack or of pulverised wood-charcoal, and forming these ingredients into a paste with a thin mixture of barley or wheat flour and water. This mixture, after being moulded by compression, is dried in air, again pressed, subjected for some time to a temperature of 80° C.; and lastly subjected for several hours to a temperature of from 1,200 to 1,300°, when they are allowed slowly to cool. The essential features of this method of construction, we may observe, are by no means novel; and sufficient experimental evidence has we think already been obtained with similar plates to justify the conclusion that M. Carrière's anode elements will somewhat rapidly disintegrate by the effect of oxidation.

Vienna.—Herr Fischer, says *Industries*, a civil engineer of this town, has obtained a concession for an electric railway between Vöslau and Rauhenstein, near Baden, and from there to Leopoldsdorf. The length of the line being considerable, Herr Fischer will probably use storage cars; Julien accumulators are now being tested in the Electrotechnical Institute, and a trial of these cells for tramway work, in competition with Reckenzaun cells, will shortly take place. A central station for the supply of electricity has recently been erected at Neuhaus, in Bohemia. The contractor is Count Czernin, a landowner in that district, and he has arranged for the supply of light to the Commune for twenty years. Power is obtained from a turbine, and there are at present two dynamo machines installed. The distribution is on the three wire system with feeders. All the leads are carried on poles overhead. The streets are lighted by eighty-five 16 c.-p. glow lamps, and in private houses there are at present 365 lamps fixed, but the demand is constantly increasing. To provide against breakdown a battery of 1,000 storage cells is now being laid down.

Paris Theatres.—The superior Commission on theatres recently held its second sitting, under the presidency of M. Léon Bourgeois, prefect of police. This sitting was almost entirely devoted to the important question of rendering uninflammable the stage decorations and the woodwork in connection with them, whatever might be the method of lighting adopted. In regard to the shifting scenery, the Commission made a distinction between theatres which are still lighted wholly or in part by gas, and those in which electric lighting is solely employed. In the former, the movable scenery should be prepared with some fire-resisting composition; as regards the latter, in cases where the electric installation is approved by the technical sub-commission, the administration may, exceptionally, dispense with such process. On the motion of Capt. Krebs, the Commission decided that the wooden supports of the electric light leads, everywhere within the theatre, should be rendered fire-proof. Finally, M. Strauss brought about the passing of a resolution in which the necessity for the electric lighting of theatres was recognized in principle. The further consideration of the question was adjourned to the 23rd ult.

The Paris Exhibition.—A meeting in connection with this exhibition was held on Wednesday at the Mansion House, under the presidency of the Lord Mayor. The electrical section was well represented by Mr. E. Graves (president of the Society), and Mr. W. H. Preece, F.R.S. (past-president). The Lord Mayor said, among other things, the Government had decided not to take any official part in the exhibition, though they had undertaken to give all facilities within their power to intending exhibitors. He had received an intimation from the Foreign Office assuring him that the Government could in no way object to his assuming that position, and stating, without qualification, that Lord Salisbury would in no way regard his presidency as opposing the position which the Government had taken in the matter. The names of an exceedingly strong and influential committee were read, and it was stated that the London, Chatham and Dover Railway Company, and the South Eastern Railway Company, had promised every facility possible, and to deal with extreme liberality on all points relating to the exhibition. A number of resolutions were proposed and carried, and a guarantee fund announced to which various contributions were there and then promised.

The Telephone in Germany.—The following figures show the considerable progress made in Germany during the last year in the adoption of telephonic communication:—

	Oct. 1, 1887.	Oct. 1, 1886.	Oct. 1, 1885.
Number of networks	150	118	92
" " subscribers	23,968	18,245	12,897
Length of lines in kilometers	4,341	3,705	2,597
" " wires " "	39,539	31,254	23,450
Number of telephonic stations	4,134	3,638	—

On Oct. 1 last, the number of inter-urban lines was 49, and 9 others were in course of construction. For some time past, Silesia and Westphalia have possessed a vast telephonic installation, covering the whole territory and connecting the different towns. A similar network is about to be constructed in the important industrial district of Saxe, and will include Chemnitz, Zwickau, Werdau, Krimitschaw, Plauen, Meerane and Leipzig. All the lines in this district are to be of phosphor-bronze, which appears likely to be generally employed, to the exclusion of iron, for telephonic lines. It was used by the administration for the first time in the line between Berlin and Hamburg. Another item of news is the adoption of an underground system for these two towns.

Japan.—Thanks to the endeavours of the Belgian Minister in Japan, Mr. G. Neyt, who undertook to make known to the Japanese Government the invention of the well-known Belgian electrician Van Rysselberghe, the telegraphic network of that country will soon be utilised for telephony also. All the apparatus required for an experiment has just been ordered in Belgium according to the instructions given by Admiral Enomotto Takaki, Minister of the Empire of Japan. A fact worth mentioning to those interested in the applications of electricity occurred in Japan in connection with Van Rysselberghe's invention, viz., before the Government had finally adopted the system, by desire of H. E. Inouyé Masaru, Vice-Minister of Public Works, a Mr. J. Fujioka, Instructor at the Engineering College at Tokio, had reported very fully on the advantages to be derived from using the system on the telegraphic lines in Japan. From simple data extracted from the books by Mr. Buels and Mr. Ch. Mourlon on the system in question, he had succeeded in applying it to a telegraph line, using apparatus which he borrowed from the laboratory of the Engineering College at Tokio. He had a complete success, and was thus able to carry out an experiment which speaks highly for the enterprise and the technical knowledge of the Japanese.

The S.S. "Ocean."—This is a steamer built by Messrs. Russell and Co., Greenock, for the oil trade, carrying the cargo in bulk; there are eight oil tanks, with a carrying capacity of 3,500 tons. On Friday last a large company met on board, consisting of owners and friends, builders, and several eminent engineers, to witness the trial of engines and electric light. The vessel left the James Watt dock about 10 a.m. and proceeded to run the measured mile, which was done several times to the entire satisfaction of owners and engineers, the speed being over $11\frac{1}{2}$ knots; the guaranteed speed was to be $10\frac{1}{2}$ knots. The electric light plant was then carefully examined and tested, and gave entire satisfaction. The plant consists of 50 20-c.p. Swan lamps distributed over the ship, and into the signal lights, masthead, and anchor lights. The binnacle also is lighted by means of the electric light. No other lights will be allowed on board, in order to ensure as far as possible safety against explosion and accidents such as have occurred on board other steamers in this trade. The dynamo employed is the Clyde Dynamo, driven by a vertical engine, and is supplied and fitted up by J. H. Carruthers and Co., under the personal superintendence of Mr. James Campbell. The speed of dynamo is 1,100 revolutions per minute, and the machine shows no signs of sparking at the brushes.

The Sesemann Ammeter.—This instrument, which can be used also as a voltmeter, is based on Joule's law $\left(\text{Heat} = C^2 Rt = \frac{E^2}{R}t = CEt\right)$, and is composed of two externally similar mercurial thermometers, one of which contains in its bulb a resistance R, formed of a spiral of German silver wire, with its ends connected to the terminal screws of the apparatus. A current being passed through this wire for a given unit period, we have—calling H the heat developed:—

$$C = \sqrt{\frac{H}{R}} \quad \text{and} \quad E = \sqrt{HR}.$$

The value of H may be taken as the difference of the tem-

peratures indicated by the two thermometers. In practice a moveable scale, graduated in amperes or volts, is employed, the zero on this scale being adjusted to the height of the normal thermometric column. The height of the second column then indicates directly the value of C or E in amperes or volts. For rough practical purposes at least we think this instrument likely to be useful; but we fear that the inventor is somewhat too sanguine in limiting the possible error to one per cent., since a considerable time is requisite to obtain thermic equilibrium, and during this time a loss of heat occurs by conduction and radiation. Moreover, unless the wire spiral be effectively insulated from the mercury, the value of R would not be constant, and the instrument would require frequent re-calibration. It is possible, however, that these objections may be to a great extent overcome.

Bournemouth.—A large audience assembled in the theatre at Bourne Hall on Wednesday evening to hear a lecture from Mr. W. Lynd, M.S.T.E., on the electric light. The pretty little theatre of Dr. Philpotts' well-known establishment was illuminated for the occasion by an installation specially fitted up by the Electrical Power Storage Company, besides Dr. Philpotts' private installation, which comprises an arc light of 500 c.-p. and a number of incandescent lamps. The lights supplied from accumulators were suspended by flexible silk-covered wires above the stage, various coloured shades being successfully brought into requisition to soften the glare of the lamps. A very pleasing effect was produced when the light was turned on. Mr. Lynd, at the outset, spoke of the labours of Faraday, whose original experiment with the permanent magnet and the moving coil of wire he demonstrated to the audience. The next experiment was the production of the electric arc, the temperature of which, Mr. Lynd said, was almost inconceivable. Iron fuses at 1,200deg. F., platinum, the most refractory metal known, at 3,000deg. F. The temperature of the electric arc is equal to 8,500deg. F. A tolerably thick piece of wire was connected with only one storage cell, when in a second or two the covering was destroyed, and the wire rendered incandescent. The principle of the dynamo was next explained, illustrated by a machine which the lecturer worked by hand. Mr. Lynd explained some of the systems of electric lighting now in vogue, and afterwards proceeded to describe in popular language the storing of electrical energy.

Indian Telegraph Department.—In the House of Commons, Mr. King asked the Under-Secretary of State for India whether he would lay upon the table a copy of the dispatch of the Secretary of State with reference to the block in promotion and other grievances of the Telegraph Department in India; whether any officers of the department had as yet accepted the offer for retirement made in that dispatch; whether, under the system of grading instituted by that dispatch and the abolition of the privilege hitherto in favour of officiating promotions being from grade to grade, many officers were mulcted of a large percentage of their emoluments while the Government saved a very large sum; on what grounds permanent promotions were fixed by the dispatch to be made only twice a year, on April 1 and October 1, and whether he was aware of any precedent for such a provision in any other service of the Crown; whether the fixing of March 31 as the latest date for the submission of retirements had practically operated to take away the inducements for retirement in nearly all the cases, if not in every case, where retirement under the regulations of the dispatch would have offered any advantage; and whether, in the circumstances, the Government would reconsider its proposals. Sir J. Gorst answered: (1) Yes, if the hon. Member will move for it, I will lay it on the table. (2) None. (3) No officers are damaged, as the rights of all existing officers are safeguarded. (4) No such provision is made in the dispatch. It was introduced by the Government of India, but no reasons for it have been communicated to the Secretary of State. (5) The date, March 31, was fixed to give every officer ample time for consideration. The Secretary of State is not aware that the inducement to retire has been taken away thereby. (6) The Secretary of State will wait till March 31 before further considering the matter.

Cost of the Telegraph Service.—In accordance with the order of the House of Commons, a return is published showing the gross amount received and expended on account of the Telegraph Service during the year ended 31st March, 1887. From this it appears that the gross amount received for telegraphic messages, private wire rentals, special wire rentals, &c., was £2,035,124. 7s. 3d., out of which sum £189,962. 3s. 11d. was paid to the submarine telegraph companies, and £4,001. 7s. 4d. was refunded to the senders of messages. The amount of extra receipts was £14,525. 5s. 5d.; sale of old materials, £78. 15s. 5d.; sale of waste paper, £2,188; and the value of telegraph services performed for other departments, without remuneration, is set down at £29,206. 17s. 10d. The total expenditure is £2,032,632. 8s. 10¾d., being £145,472. 14s. 2¾d. more than the receipts. The expenditure is made up as follows:—Salaries, rent, maintenance of telegraphs, &c., £1,939,764. 3s. 4¾d.; amount expended by Office of Works, London, from the grant for Revenue Department Buildings in respect of telegraph service, £51,278. 2s. 3d.; stationery, £35,259; buildings in Ireland, £2,699. 0s. 11d.; stamps used on telegrams, £334; cost of auditing accounts, £2,193. 9s. 7d.; and rates and contributions in lieu of rates, £1,104. 12s. 9d. Appended to the accounts is a statement of the amount expended on account of the annual charge for the securities created for the purpose of the Telegraph Act. The capital stock is set down at £10,880,571. 5s. 2d., the year's interest being £326,417. 2s. 9d. Adding the excess of expenditure over receipts as given above, the total deficiency of telegraph revenue to meet expenditure and the interest on telegraph stock created in the year ended March 31 last is £471,889. 16s. 11d. The deficiency in the year ended December 31, 1872, was £118,966. 1s. 1d., and this has now grown to £3,024,899. 10s. 5d.

Berlin.—The first central station, says *Industries*, in which accumulators are used has been recently started in Berlin, at No. 37, Neue Friedrichstrasse. The plant consists of two 45 h.-p. Babcock and Wilcox boilers (manufactured by Messrs. Schmidt, of Küstrin), two steam engines of 35 h.-p. each, and two 18 kilo.-watt dynamos. The current is not supplied direct from the dynamo, but from a battery of flat tray pattern Khotinsky accumulators, each cell having 600 ampere-hours' capacity. The principal customer at present is a restaurant situated under the elevated railway, and a total of 500 hundred lamps is now installed; but applications for the light from neighbouring places have been received, and to provide for the extension the battery boxes have been made deep enough to admit additional plates, by which the capacity can be increased by another 600 ampere-hours. The lamps used are 150-volt Seel

lamps, and the total cost of the central station and mains was £3,500, that is, at the rate of £7 per lamp fixed. A few weeks ago I gave particulars of the electric light installation in what is known as the German theatre of this town. I am now enabled, by the courtesy of the engineer in charge, to give you details of the installation and working expenses. When gas was used in this theatre, the cost for lighting varied from £4 per day in summer, to £5. 10s. in winter; but now, with the electric light, the working expenses do not materially vary with the season, as the items of attendance and interest on the plant are a constant. The total cost of the installation was about £3,000, and this contains the following items: Engine house and chimney, £500; boiler and engines, £940; dynamos, wiring, and accessories, £905; electric light fittings, £250; and regulator for the stage, £150. The consumption of coal in winter is about 16cwt. daily, costing 18s.; attendance, 8s.; lubricant, 3s.; and interest on the capital outlay 20s., reckoning this at 10 per cent. for 300 working days. The installation has been in use too short a time to estimate accurately the cost of renewal of lamps, but this could hardly exceed 10s. a night, so that the total expense for the electric light may be taken as £3 per night, which is considerably below the sum previously paid for gas.—At a meeting of the Town Council, held on the 16th ult., it was resolved that the wiring of private houses may be left to open competition, but that the work in connection with bringing the current into the house and the installation of the meter must be undertaken by the Berlin Electric Company.

Bradford.—Dr. Hopkinson has reported upon the system of electric lighting he would recommend for the proposed installation, and, as it has been approved of, tenders will shortly be invited to complete the installation. Dr. Hopkinson's report shows that he is in favour of having the central station at Bolton-road. The report prefers the direct system, it having the advantage that a continuous current is used, available at pleasure, for charging accumulators or for transmission of power. Dr. Hopkinson recommends the three-wire system. The advantage of this system is that it saves about 12 per cent. of the electrical power, a proportionate saving in the cost of engines and dynamos, and a considerable saving in the cost of conductors. Referring to the dynamos, Dr. Hopkinson says he would incline to use five, but, at the same time, he adds a smaller number of larger machines would be perfectly successful, and would possess certain advantages over the larger number of smaller machines. The contractor should guarantee a commercial efficiency of 90 per cent. for the dynamo, and the wires should be laid in brick trenches. On the method of charging for payment Dr. Hopkinson says:—"It is very much more costly to store electricity than to store gas, consequently you must provide a plant competent to meet the maximum demand. A consumer, then, who takes his supply for half an hour at the time when the demand is a maximum will cost you as much as a consumer who takes the same supply during seven or eight hours, provided those hours are the hours when the demand falls short of the maximum. You must keep your machinery running, and the only difference between running with a fair load and a light one is a small addition to your coal bill. Again, although there are many meters which will measure electricity, they are more or less costly, and sufficient time has not yet elapsed to test them for wear and tear. . . . I should, therefore, advise at first, at all events, that you should charge by agreement with the customer. The basis of this agreement should be the maximum which the customer will take. You would put an instrument upon his service main which would cut him out if he seriously exceeded his maximum. With regard to the hours of work, Dr. Hopkinson considers that it would be best to begin by running from a little before sundown until perhaps one or two o'clock in the morning. The hours could be extended to an extent justified by the demand. In his judgment, the Corporation should not undertake the fitting up of houses for the electric light; but it should keep the most absolute control over the way in which the wiring is done." We shall probably have something more to say regarding this matter.

Electric Lighting in France.—The town of Saint-Fargeau (Yonne) has obtained an installation of electric lighting in virtue of an annual subvention of 2,000fr. voted by the municipality, and in consequence also of the support of M. Tusseau, a manufacturing locksmith belonging to the town. The motive-power is obtained from a neighbouring watercourse. The town of Grenade-sur-Garonne, also, recently inaugurated a central station, working 500 incandescent lamps; the installation having been carried out under the superintendence of M. Bonnet, the engineer, and M. Jougla.—In reference to the central station at Nancy referred to in our last issue, we are able to supply the following additional particulars. The installation comprises three steam engines, each of 150 h.-p., of which two are in use at the same time. These actuate respectively the alternating and the continuous current dynamos; the system of distribution employed being dependent upon the distance of the lamps from the station. As yet, only 900 lamps are in operation. Special terms are granted to the cafés making use of the light. The works are established in what was formerly a convent, and more recently a military barracks, the premises being let to the town for 1,000fr. per annum. The greatest activity prevails in relation to this enterprise, the concession for which was granted by the Municipal Council mainly with the view of obtaining a reduction in the price of gas. Hitherto, however, no such reduction has been rendered necessary; for, strange to say, instead of diminishing, the consumption of gas has augmented since the opening of the electrical works; thus, for the month of January last, it was 10 per cent. greater than in the corresponding month last year, that is higher than it has ever been previously.—The theatre at Claremont-Ferraud has for some weeks past been lighted by electricity. The installation comprises a 16 h.-p. double cylinder Otto gas engine, an Edison dynamo, a set of accumulators, and 130 Edison lamps of from 10 to 20 candle-power, distributed on the stage and in the various offices. A Pieper arc lamp, placed above the entrance, is worked during the *entr'actes*. Besides the sum of 25fr. per night paid by the director of the theatre for the illumination of the stage, the contractors for the lighting—who are none other than the Gas Company—receive from the town an indemnity of 30fr. per night for a minimum of 100 performances per annum.—It is announced that a central station will shortly be opened at Mende. A first trial of the lighting at the Hotel de Ville was made at the end of January last, and it is expected that the works will be completed within a month. This station, the establishment of which was projected several years ago, is due to the labours of M. Lamy. It is to provide both for private and public lighting—the town of Mende being one of the few prefectures which have not yet been supplied with gas.

TRANSFORMERS OR ACCUMULATORS?

The subject of electric distribution by alternating currents and transformers has occupied the Institution of Electrical Engineers for three evenings, and, as usual, the discussion contained a good deal of useful matter, besides a certain amount of information or opinion which might be called irrelevant. The latter did not, however, preponderate, and, as far as it went, was rather instrumental in imparting a more lively tone to the proceedings. When new and special subjects come before a learned society, there are probably not ten members out of every hundred who are able to speak strictly to the point. In the present instance it was rather creditable to the remaining ninety that they did not unduly spin out the discussion by general talk, and so waste the time of the meetings. A little leavening of the heavy scientific arguments of the specialists is, however, not objectionable, and of such leavening there was just sufficient. The object of societies like the Institution of Electrical Engineers is mainly practical. Papers are read and discussed not so much with a view to advance pure science as with the object of showing how scientific discoveries may be practically applied for business purposes, and as this object is more or less attained, so must we consider the papers and discussion more or less useful, irrespective of their merits from the point of view of pure science. The question, therefore, is what useful lesson did the last three meetings of the institution teach electrical engineers?

Viewed in this light, last week's discussion was far more useful than that of the previous week, and even than the papers which provoked it. Mr. Kapp's paper showed what could be done by transformers, whilst Mr. Mackenzie's paper described what had actually been done. Both subjects are of importance in themselves; but of far greater importance is it to know what place the transformer system occupies when compared with other systems of distribution, and it was this comparison which gave special value to last week's discussion. We do not propose to review the discussion in this place, as we shall in due course report it at some length; but we may draw some practical conclusions from the remarks made by the various speakers. Briefly described, the discussion was a contest between the advocates of distributing electricity by means of continuous currents and secondary batteries on the one hand, and the partisans of distribution by alternating currents and transformers on the other hand. Direct supply from the dynamos to the lamps was necessarily excluded, because neither of the rival systems would be used in central station lighting when the area of supply is limited. In such cases there is no need to employ high tension currents, and, therefore, no need to use transformers, although storage batteries would undoubtedly be of advantage. They would be used not for the purpose of reducing the quantity of copper in the mains, but simply as a precaution against interruption in the supply through an accident to the machinery, and also to enable the machinery to work at full output for longer periods, a condition of working which evidently secures greatest economy as far as the engines and dynamos are concerned. Whether this increase of economy will not be more than counterbalanced by the waste of energy in the batteries and by the cost of renewal of plates, is a matter which depends entirely on the perfection of the particular battery employed. Up to the present, the system has not been adopted to any large extent. As far as we know, it is not used in central station lighting in America; and in Europe there are, we believe, only five stations so worked—one in Kensington, two in Berlin, one in France, and one in Vienna. In the four first-named installations the batteries do not act as transformers for toning down the high pressure of the dynamos to the 100 volts or so, required by the lamps, but in the Vienna installation the batteries perform this function. The high pressure service there is at between 400 and 500 volts, and the batteries are divided into four groups, each supplying separate sets of lamps at 100 volts. The fact that out of the many hundred central stations only a very few use storage batteries seems to show that up to the present, at all events, those responsible for the erection and working of these stations either do not consider batteries necessary, or if they recognise their usefulness, have not sufficient confidence in them to incur the expense of their adoption. We are inclined to think that the latter is the true reason. Once let it be proved that storage batteries are perfectly reliable, fairly efficient, and not too dear, and their adoption for central stations working at 100 volts, or a little over, will be secured. There is an enormous field for the makers of secondary batteries. It is an open secret that profits on the manufacture of dynamos have of late declined almost to the vanishing point. The competition is exceedingly keen, and customers are very exacting. To put it bluntly, the market is spoilt. With batteries this not so. There is hardly any competition, and buyers of these appliances have as yet had no opportunity to become hypercritical. They are easily satisfied, and will remain in this complacent frame of mind until the perfect battery has been invented. Whoever is first in the field with a really good, even if not perfect, battery will reap a golden harvest.

Having admitted the importance of batteries for a central station supplying only home circuits—that is, circuits extending only to such moderate distances as can be supplied on the direct low-tension system—let us see how the case stands with long-distance service. In the first place, it must be borne in mind that the batteries would have to be charged from a high-tension current; and here we are at once confronted with two difficulties. One is the insulation of the batteries from earth, and the other is the dynamo itself. When the difference of potential between the first and last cell of a battery is only 100 volts, the insulation presents no great difficulty, and in many cases no further precaution than placing the cells on wooden stands is used. But when ten or twenty of such batteries are charged in series, the potential difference between the first and last cell in circuit will amount to 1,000 or 2,000 volts, and although the batteries may be miles apart, their tendency to leak to earth must obviously be the same as if all stood in the same room. To place the cells on wooden shelves would in this case be insufficient insulation, and it would obviously be necessary to use some high-class oil insulator. This can be done at some little expense, but there is another difficulty of insulation to be faced. If each battery is coupled to its own lighting circuit whilst the charging current is on, the leak would take place between the lighting circuits and earth; and, moreover, it would be highly dangerous to touch any part of the lighting circuit. It will therefore be necessary to disconnect the lighting circuits from the batteries whilst the latter are being charged, and as the supply of current cannot be interrupted, it follows that duplicate sets of batteries must be employed. We have assumed above that all the batteries are charged in series, but our reasoning also applies to batteries charged in parallel, an arrangement which will be preferable for working in connection with a network of street mains, because a failure of one battery would not entail extinction of the lights ordinarily fed by it. But assuming that we have installed a sufficient number of duplicate batteries at various points of the network, that we have insulated each battery from earth in an absolutely reliable manner, and that we have provided interlocking switches of such construction that it is impossible to couple any battery being charged to the lighting circuit,—we have yet to provide a charging dynamo. Now this dynamo should have a high efficiency, and work without sparking. Is there such a machine in the market? We doubt it. Prof. Silvanus Thompson pointed out that an ordinary gramme commutator is quite unsuitable for use with an armature giving 1,000 or 2,000 volts. For such pressures we must use a Thomson-Houston, or a Brush machine, either of which has necessarily a lower efficiency than any of the better low tension machines now in the market, and probably also a lower efficiency than modern alternate current machines. Mr. Crompton proposes to limit the pressure to 500 volts, as he has done in the Vienna installation, and to work the lamps from a sub-divided battery, which might or might not be charged at the same time. If a good earth occurred at one end of his battery, a person touching the lamp wire connected to the other end would receive a shock of 500 volts, and, although this may not be fatal, we doubt whether

consumers would care to run the risk. But apart from this consideration, if the limit of 500 volts be adopted, it is evident that the battery system of distribution will only be applicable over comparatively small districts, and cannot, therefore, compete with the transformer system using currents at 2,000 volts or more. To bring the two rival systems upon even terms, we must assume the pressure to be the same in both, and, therefore, Mr. Crompton's simple plan of charging and lighting at the same time becomes impracticable. This does not, however, preclude the use of batteries for long distance central station lighting. We have sufficient confidence in modern electrical engineering to expect that by degrees all the various difficulties we have enumerated will be overcome and perfect batteries will be available. Then and only then will it be feasible to distribute electricity by high tension continuous currents. But what is to be done in the meantime? Are we to abandon all ideas of central station lighting other than by home circuits extending only a few hundred yards from the dynamos? Obviously not. We can work with alternating currents to any reasonable distance, and, having these means ready to hand, it would be folly to let business go by whilst waiting for a more perfect system. The programme laid down by Mr. Kapp in his paper is reasonable because making provision for the adoption of the more perfect system when this becomes available. He advocates the laying down of a complete network of mains as used in direct supply stations. At certain points there would be fixed large transformers feeding this network, so that only low tension wires need enter the houses of consumers. If the change becomes possible these transformers would be replaced by storage batteries, whilst the alternate current machines at the station would be exchanged for high tension continuous current dynamos. The station buildings, boilers, engines, and mains would, of course, be retained without alteration. Thus the change would be effected with a minimum of loss in discarded plant.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 129.*)

As has already been pointed out, boxes of resistance coils can not be used for the accurate measurement of small resistances, and in order to get to some extent over this difficulty, Sir William Thomson constructed boxes of conductivities. The conductivity, or conductance as it has recently been called, of a coil is the reciprocal of its resistance, and

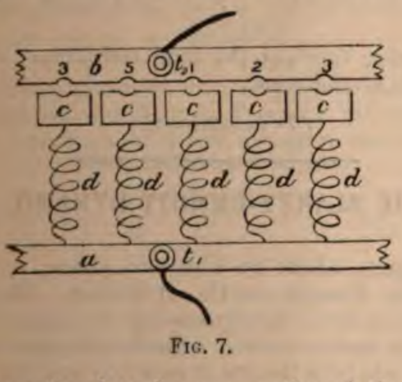


FIG. 7.

hence is proportional to the cross section of the wire forming the coil. In order to add conductances, therefore, we must add to the section of the conductor, that is to say, we must put the coils in parallel or multiple arc. The arrangement is illustrated in Fig. 7, in which *a b* represent two heavy bars of copper or brass (in Sir William Thomson's box these bars are of brass and are about one square inch in section), *c c c* are blocks of the same substance fixed to the cover of the box in such a way that they can be put in contact with *b* by means of plugs as in an ordinary resistance box. The conductances *d d d* are soldered at one end to the bar *a*, and at the other end to the blocks, *c c*. They are wound on bobbins, and are in every way similar to ordinary resistances, except that they are made of much thicker wire. The conductances are expressed in reciprocals of ohms—that is to say, a conductance of 1 is a resistance of 1 ohm; a conductance of 10 is a resistance of $\frac{1}{10}$th of an ohm, and so on. The conductances introduced by the different plugs are marked in the same way as the resistances in the ordinary boxes; and the resistance of a wire, measured by this box, is obtained by taking the reciprocal of the sum of the conductances in the box when balance was obtained in the test. This arrangement suits well for the measurement of resistances of from one ohm downwards; but for resistances much higher than that the method becomes insensitive, unless the box is so large as to be inconveniently heavy and expensive. The method has the great advantage that there are no needless contact

FIG. 8.

resistances in the circuit, and the result is only influenced by contact resistance in the proportion that the different contacts influence the conductance of their own circuits. The terminals t_1 t_2 must be massive, and kept perfectly clean. For the measurement of high conductances they are preferably made of cups of mercury.

The combined arrangement for the measurement of resistances and conductances recently introduced by Sir William Thomson, and called a "mho-ohm drum," is illustrated in Figs. 8 and 9. Fig. 8 shows a plan of the top of the drum, and Fig. 9 a section showing how the resistances are joined to the contact pieces, and how these pieces are arranged.

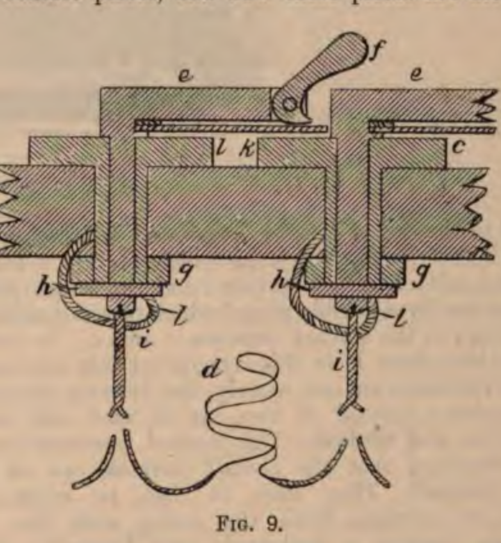
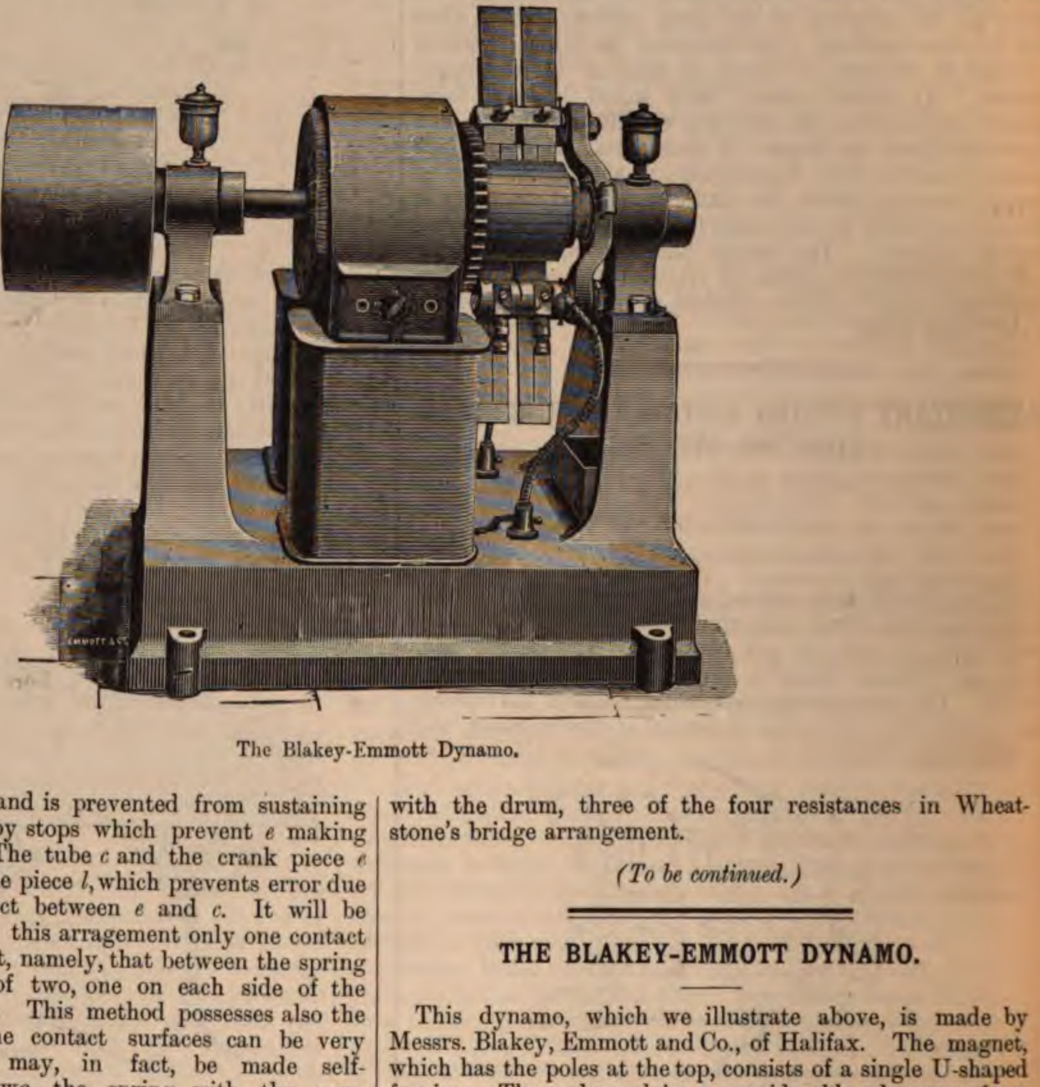


FIG. 9.

Two heavy rings of copper, *a* and *b*, are fixed concentrically to the top of the cylinder, which is a disc of vulcanite. Between these rings a series of brass or gun metal tubes with heavy flanges, *c c c*, are fitted into the vulcanite and secured by nuts, *g*; into these tubes gun-metal kneepieces, *e e*, are fitted, and held firmly in position between a shoulder bearing on the upper side of *c*, and a steel pin *h*, bearing on the lower end of the tube. Beneath the upper bar of *e* a spring, consisting of several thicknesses of thin, hard copper, is soldered; and into the end of *e*, and over the end of the spring, a handle, *f*, with a cam-shaped end, is pivoted. The resistance *d* is usually made of well-insulated

platinoid wire, and is wound on a cylinder of copper on the outside, of which a series of copper rings are soldered, so as to form channels for the coils. The channels for the coils are covered with several thicknesses of varnished paper to secure insulation, and the wire is well dried, and drawn through melted paraffin as it is wound on. Outside the coils, and in contact with the copper division rings, another cylinder of copper is placed, and screwed to several of the copper rings to secure good contact. The object of the copper cyclinders and copper dividing rings which joins them together is to secure rapidity of cooling, so as to insure small error due to the heating of the wire by the current passed through it. When this drum is used as an ordinary resistance box the rings *a* and *b* form the terminal plates, and the beginning and end of the resistance inserted in the box are put into contact with these rings by means of the proper crank pieces *e*, springs *k*, and cam handles *f*. Between these two terminal contacts the contacts are all made on the flanges of the tubes *c*. The contacts are made by turning *e* to the proper position, and pressing the spring *k* firmly into contact with *c* by means of *f*, and they serve, like the plugs in Figs. 4 and 5, to cut out resistances by short-circuiting them. The resistances are connected to the contact pieces *e* through a flexible strand *i*, which is whole of the others can be tested against it without any contact resistance or other uncertainty being introduced.

To use this drum for the measurement of conductances the contacts have to be made on the rings *a* and *b*. The arrangement only differs from that shown in Fig. 7 in not having the coils permanently connected to *a*. Fig. 8 shows the connections for placing the resistances 32 and 512 in parallel—that is, for adding the conductances $\frac{1}{32}$ and $\frac{1}{512}$ together. The resistances, 64, 128, and 256, are cut out by making the contacts from A and B on the same ring, and a similar method would be followed for any other case. The adoption of this combination adds very little to expense of the set of resistances, and, as will be readily seen, greatly increases the range of accurate measurement. A resistance of 1 ohm, for example, can be measured directly to within $\frac{1}{8000}$th of its true amount by means of a box the total resistance in which is 8,000 ohms; whereas by the ordinary box there is nothing between 1 ohm and 2 ohms. With a box containing a maximum resistance, R, or a total resistance, 2 R, the least sensibility for direct measurement is for a resistance equal to $\sqrt{R}$, and the sensibility is equal for both methods of using the box. This mho-ohm drum is usually combined with two other sets of resistances, not shown in the drawing, for the purpose of forming, together



The Blakey-Emmott Dynamo.

soldered to the end of *e*, and is prevented from sustaining damage by overtwisting by stops which prevent *e* making more than half a turn. The tube *c* and the crank piece *e* are connected by a flexible piece *l*, which prevents error due to resistance in the contact between *e* and *c*. It will be observed that there is in this arragement only one contact for each resistance cut out, namely, that between the spring and the plate *c*, instead of two, one on each side of the plug, in the plug method. This method possesses also the great advantage that the contact surfaces can be very easily cleaned. They may, in fact, be made self-cleaning by pressing down the spring with the cam, and then turning *e* backwards and forwards. There is besides the advantage that the whole of the box does not require to be in the circuit, because any part can be included between the terminal plates. The magnitude of the resistances are made in the geometrical series 1, 1, 2, 4, 8, &c., each resistance being in this way equal to the sum of all that precede it. The figure shows a drum, having a total resistance of 1,024 ohms; but a very few additional contact pieces would serve for a box of very high resistance. The advantage of making each resistance equal to the sum of those that precede it is, that the resistances can readily be tested against each other. Thus, if the one ohm be standardised at any time, the with the drum, three of the four resistances in Wheatstone's bridge arrangement.

(To be continued.)

THE BLAKEY-EMMOTT DYNAMO.

This dynamo, which we illustrate above, is made by Messrs. Blakey, Emmott and Co., of Halifax. The magnet, which has the poles at the top, consists of a single U-shaped forging. The makers claim a considerable advantage from this, as it avoids both the use of cast iron and the magnetic resistance of joints. The armature, which is of the Gramme type, is built up of thin insulated discs of annealed iron, mounted on a gun metal spider. This spider is securely keyed to a steel shaft, thus ensuring positive mechanical driving. In the machines intended for incandescent lighting there is only one layer of wire on the outside of the armature. The commutator consists of copper, specially hard drawn to the required section, and mica is used as an insulator. Special brush-holders are used, each separately adjustable, and with hold-off catches. In all sizes of machine above the No. 2 (for 50 lamps) at least two pairs of

brush-holders are provided. The rocking bar which carries the brushes can be readily moved to bring them to any desired point on the commutator. The brushes themselves are made of thin copper ribbon. The machine is mounted on a strong cast-iron base, and the bearing standards are bushed with gun metal. Light feed lubricators are used, and special means are provided for carrying off used oil from the bearings. The machine in the illustration, called the No. 3 size, is intended for an output of 6,000 watts, or 100 volts and 60 amperes, at 1,150 revolutions per minute. It is compound wound for constant potential. The resistances are:—Armature = ·059ω, series coils = ·015ω, shunt coils = 53·ω. The electrical efficiency at full load is 92·7 per cent. The total weight of copper is 132½lbs.; and in the armature alone, 13¼lbs. This gives an output of 48·5 watts per pound of copper in the whole machine, and 457·6 watts per lb. in the armature only. The total length of wire on the armature is 291·6ft., which is at the rate of 35in. per volt. The total strength of useful field is 432 lines—English measure. These machines run without sparking, and do not heat after long runs. Messrs. Blakey, Emmott and Co. (Limited) are now constructing this type in varying sizes, intended for outputs of from 600 to 120,000 watts.

MESSRS. ROBEY & CO.'S COMPOUND "ROBEY" ENGINE.

Since the commencement this year of the publication of a new series of the *Electrical Engineer*, the number of subscribers has been so much increased that far the larger proportion must find it impossible to refer to back numbers for any information published before the present year. It is our intention, therefore, to illustrate and describe the several forms of engines most in use for driving dynamo-electric machines for lighting and power transmission, and it becomes increasingly necessary that we should do this, because the number of engines likely to be required for electric lighting is now rapidly increasing. Few people have any idea of the very great amount of electrical work which is being done in London and other parts of the country, and there is no doubt that it will increase rapidly within the immediate future especially when the Electric Lighting Act has been amended.

Of the engines which have become favourites amongst electric light engineers are those made by Messrs. Robey and Co., Messrs. Marshall, Messrs. Davey, Paxman and Co., Messrs. Hornsby and Sons, Messrs. Allen, Messrs. Galloway, Messrs. Hick, Hargreaves and Co., and others, and as we happen to be first prepared with engravings of one of the engines of the former as used at the Newcastle Exhibition last year, we give that first. Of these engines there were eight of about 100 indicated horse-power each, and two horizontal engines. A horizontal engine by the same firm, with the Pröell cut-off gear, was used for driving the machinery in motion.

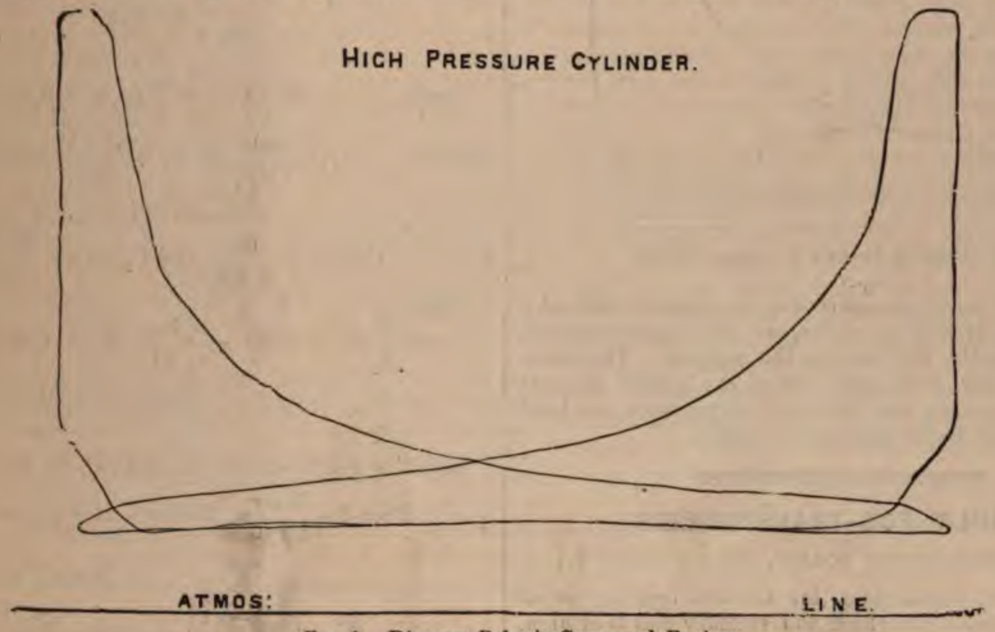


FIG. 1.—Diagram Robey's Compound Engine.

The engine which we illustrate is a compound engine with cylinders of 12in. and 21in. diameter, and a stroke of 24in., the normal speed being 100 revolutions per minute. It is fitted with Richardson's governor and radius link automatic cut-off gear, by which a practically uniform speed is maintained under varying load. This gear is clearly shown in the perspective view which we give on page 204, and its efficiency may be gathered from the indicator diagrams which we give herewith. The steam pressure employed was 120lb. per square inch, and when the diagrams (Figs. 1 and 2) were taken the load was rather light, as shown by the early cut-off seen in the high pressure diagram. The expansion line of the diagram (Fig. 1) may be considered perfect, and no improvement can be desired in the low pressure diagram, which is necessarily of a form very different from that from the high pressure cylinder, inasmuch as the former receives its steam from the limited supply of the high pressure cylinder and intermediate receiver. The high pressure diagram (Fig. 3) was taken when more work was being done, but it will be seen that the admission, cut-off, and expansion, are all equally perfect, the cut-off being exceedingly sharp and the expansion line correspondingly close to the theoretical curve. The wavy line in the expansion curve, especially in the left-hand diagram, is due partly to the oscillation of the indicator parts, and perhaps also partly due to the condensation and re-

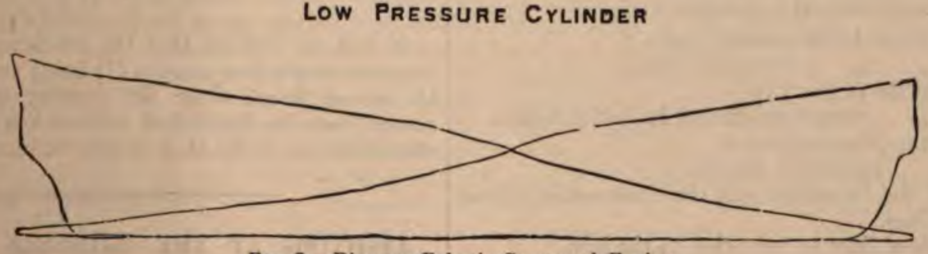


FIG. 2.—Diagram Robey's Compound Engine.

evaporation of steam in the first stage of the expansion. We are informed that repeated tests of these engines have given a consumption of under 2lb. of Welsh coal per indicated horse power per hour, or under a ton of coal for 100 horse-power for 10 hours.

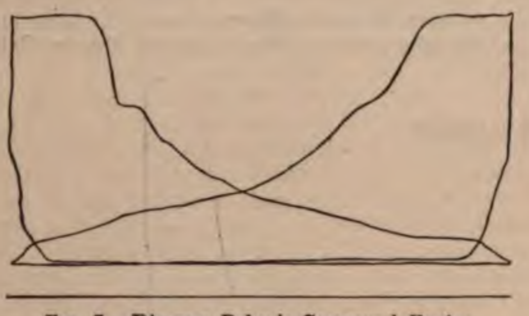


FIG. 3.—Diagram Robey's Compound Engine.

Such a result could not, of course, be obtained without a first-class boiler as well as engine, and the locomotive type adopted is no doubt the best for the purpose. The workmanship of boiler and engine are of the highest class, as our readers are aware, and with the high pressure now used none but the best boiler making will suffice.

FORMULÆ FOR TRANSFORMERS.*

BY PROFESSOR GEORGE FORBES, F.R.S. (L. AND E.)

The modern transformer for electric lighting is an induction apparatus in which the primary coil is of high, and the secondary of low, resistance, consisting of two ring coils of insulated copper wire enclosed in an iron sheathing, so subdivided as to prevent the formation of local currents in the iron when subjected to the influence of alternating electric currents in the coils. The terminals of the primary are kept at a constant mean difference of potential. The secondary circuit includes the lamp circuit, and is of varying resistance. The iron is so situated with respect to the coils that there is no free magnetism; this simplifies the mathematical treatment of the phenomena.

It is required to predict (1) the magnetic induction in the iron, (2) the work given off to the lamp circuit, (3) the whole work absorbed by the apparatus, (4) the waste of energy when no lamps are in circuit, and (5) the effect which will ensue from varying the construction of the apparatus. The first of these has been approximately solved on the assumption that the permeability of the iron is constant.†

It is generally assumed that in such a system of electrical distribution the electromotive forces, the electric currents, and the magnetic induction are simple harmonic functions of the time. This would not be the case if the phenomenon called by Ewing "magnetic hysteresis" is taken into account, and in a preliminary investigation this must be omitted. Its effect in practice is insignificant so long as the magnetic induction in the iron is not high.

The notation now adopted is as follows :—

p_1 = number of turns in the primary coil.
p_2 = ,, ,, ,, secondary coil.
r_1 = resistance of the primary coil.
r_2 = ,, ,, secondary circuit, including lamps.
c_1 = current in the primary circuit.
c_2 = ,, ,, secondary circuit.
m = integral of the induction over the cross-sectional area of the iron.
$\rho = \dfrac{\text{mean length of lines of induction in the iron.}}{\text{cross-sectional area of iron} \times \text{permeability.}}$
$n = \pi \times$ number of alternations of E.M.F. per second;
$= 2\pi \times$,, ,, complete periods of E.M.F. per second.
w_1 = work done in unit time by the primary current.
w_2 = ,, ,, ,, in the secondary circuit.
e = difference of potential of primary terminals.
C.G.S. units are adopted throughout.

* Paper read before the Society of Telegraph-Engineers and Electricians on the 9th February.
† J. Hopkinson, *Proc.* Roy. Soc., 1887.

Assume $$m = \mathrm{M} \sin nt \quad . \quad . \quad . \quad . \quad . \quad (1)$$

then $$c_2 = -\frac{p_2\, dm}{r_2\, dt} = -\mathrm{M}\, n \frac{p_2}{r_2} \cos nt \quad . \quad . \quad (2)$$

and
$$w_2 = \int_0^1 c_2^2 r_2 dt = \frac{\mathrm{M}^2 n^2 p_2^2}{r_2} \int_0^1 \cos^2 nt = \frac{\mathrm{M}^2 n^2 p_2^2}{2 r_2} \int_0^1 (1 - \cos 2\, nt)\, dt.$$

The mean value of the periodical part is zero. Hence
$$w_2 = \frac{\mathrm{M}^2 n^2 p_2^2}{2 r_2} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Again, $$\mathrm{M} \sin nt = \frac{4\pi}{\rho} . (p_1 c_1 + p_2 c_2);$$

whence $$c_1 = \frac{\mathrm{M} \rho}{4 \pi p_1} \sin nt + \frac{p_2^2 n \mathrm{M}}{p_1 r_2} \cos nt \quad . \quad . \quad (4)$$
$$= \mathrm{C}_1 \sin (nt + \alpha),$$

if $$\mathrm{C}_1 \cos \alpha = \frac{\mathrm{M}\rho}{4\pi p_1} \text{ and } \mathrm{C}_1 \sin \alpha = \frac{\mathrm{M} p_2^2 n}{p_1 r_2}.$$

Again,
$$c_1 = \frac{\mathrm{E}}{r_1} \sin (nt + \beta) - \frac{p_1}{r_1}\frac{dm}{dt}; \text{ if } e = \mathrm{E} \sin (nt + \beta),$$
$$= \frac{\mathrm{E}}{r_1} \cos\beta \sin nt + \left(\frac{\mathrm{E}}{r_1} \sin\beta - \frac{p_1 \mathrm{M} n}{r_1}\right) \cos nt \ . (5)$$

Equating coefficients in (4) and (5), we have
$$\mathrm{E} \cos \beta = \frac{\mathrm{M} \rho r_1}{4\pi p_1}; \ \mathrm{E} \sin \beta = \mathrm{M}\, n \left(p_1 + \frac{p_2^2 r_1}{p_1 r_2}\right)$$
$$= \mathrm{M}\, n\, p_1 \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right);$$

whence $$\frac{\mathrm{E}^2}{\mathrm{M}^2} = \left(\frac{\rho r_1}{4\pi p_1}\right)^2 + n^2 p_1^2 \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right)^2 \quad . \quad (6)$$

also, $$w_1 = \int_0^1 c_1 e\, dt = \mathrm{C}_1 \mathrm{E} \int_0^1 \sin (nt + \alpha) . \sin (nt + \beta) . dt$$
$$= \frac{\mathrm{C}_1 \mathrm{E}}{2} \int_0^1 \{\cos (\alpha = \beta) - \cos (2nt + \beta + \alpha)\}\, dt$$
$$= \frac{\mathrm{C}_1 \mathrm{E}}{2} \cos (\alpha - \beta) = \frac{\mathrm{C}_1 \mathrm{E}}{2} (\cos \alpha \cos \beta + \sin \alpha \sin \beta)$$
$$= \frac{\mathrm{M}^2}{2} \left\{ r_1 \left(\frac{\rho}{4\pi p_1}\right)^2 + \frac{n^2 p_2^2}{r_2} \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right) \right\} \quad . \quad . \quad (7)$$
$$= \frac{\mathrm{E}^2}{2} \cdot \frac{r_1 \left(\frac{\rho}{4\pi p_1}\right)^2 + \frac{n^2 p_2^2}{r_2}\left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right)}{\left(\frac{\rho r_1}{4\pi p_1}\right)^2 + n^2 p_1^2 \left(1 + \frac{p_2^2 r_1}{p_1^2 r_2}\right)} \quad . \quad . \quad (8)$$

When the actual figures pertaining to a modern transformer are inserted, it is found that the quantity $\frac{p_2^2 r_1}{p_1^2 r_2}$ is less than ·01; that the first term of the numerator in (8) is small compared with the second; and that the first term of the denominator is very small compared with the second.

The efficiency is found by dividing (3) by (7).

When no lamps are used on the secondary circuit, the rate of work done is, by (7) (r_2 being infinite),
$$\text{waste} = \frac{\mathrm{M}^2}{2} r_1 \left(\frac{\rho}{4\pi p_1}\right)^2.$$

It will be noticed that the efficiency of the apparatus depends on the first term in (7) being small compared with the second; hence n (or the number of alternations per second) may be diminished without loss of efficiency if ρ be diminished, or if the mass of iron be increased.

LIGHTING AT THE BRUSSELS EXHIBITION.

In order to make a special feature of the lighting, as of the telephonic service, the executive committee has entrusted all the arrangements for the former to one of its members, M. Charles Mourlon, with the assistance, as "ingénieur, chef de service," of M. A. Bandsept. The committee has asked the co-operation of the principal electric lighting companies and contractors in Belgium and other countries; and arrangements have been so made that the greatest possible number of competitors may engage in lighting

the buildings and gardens. The lamps will be supplied gratis, but will compete for several valuable prizes, other special prizes being offered for lamps working under exceptional conditions of yield and economy.

Among the Belgian participants in this lighting contest are the Phœnix Company of Ghent, M. Dulait Fils, of Charleroi; MM. Bouckaert et Cie., Herr Eduard Rau, representative of Siemens and Halske, of Berlin; M. Goffin, director of the Société Industrielle d'Electricité, Brussels; M. Pieper and MM. Gérard et Cie., of Liége, who intend to lay down a distant transmission like that they established between the Laeken Gasworks and Brussels Opera House, for lighting its stage. Among the most important participants out of Belgium are the Société Suisse d'Electricité, of Lausanne; Mr. Bury, of Manchester; the Bernstein Company, of London; the Compagnie Cuenod et Sautter, of Geneva; Ganz and Company, of Buda Pesth; the Gülcher Company, of London; the United Electrical Engineering Company (Jablochkoff), London; the Thomson-Houston International Electrical Company, of Boston; and the Anglo-American Brush Electric Light Corporation, of London, who will light the British section of 15,000 sq. m., or 161,465 sq. ft. area.

The project for lighting the exhibition comprises three distinct parts—that by electricity of the buildings and annexes; that of the façades and fountains; and that of the gardens, provisionally by gas supplied gratis by the Brussels Municipal authorities, and eventually by electricity. The great object kept in view has been to afford a contrast between a divided light, spread in profusion over the plantations, kiosques, &c., in the park on the one hand, and the sober grandeur of a concentrated light illuminating the buildings in the background.

The exhibition buildings embrace two rectangular pavilions, as they are called, which were built for the National Exhibition of 1880; one will be devoted to retrospective fine art and the other to fêtes and ceremonials. They are connected by a circular colonade of more than 200 metres length; and in the middle will be erected the King's Pavilion. The Grand or Machine Hall, situated behind the colonade and King's Pavilion, is 250 metres = 820ft. long, 6m. = 223ft. wide, and 23m. = 75ft. high. Two annexes, 100m. = 328ft. long by 60m. = 197ft. wide, terminate this portion.

The lighting of the Machine Hall will be effected by 84 arc lamps chosen from the systems of Piette and Krizig (Bouckaert et Cie), Dulait (Soc. An. Electrique et Hydraulique), Thomson-Houston, De Puyt, Jaspar, and Pitd (Soc. An. Electr. et Hydr.). According to the nature of the installation adopted for the engines and the metallurgical exhibits, the Machine Hall will be lighted, either with fifteen 2,000-c. arcs in the central avenue and thirty-two 1,500-c. and forty 1,200-c. arcs disposed in the lateral compartments, or thirty large arcs arranged in groups of five at the ends of the hall, with lamps of less intensity grouped about the middle of the hall. These lamps will be hung at heights varying from 7 to 10 metres, that is to say, from 23 to 33 feet, and at distances apart of 10 and 16 metres, or 33 and 52 feet.

The wings of the Machine Hall, 15m. or 50ft. high only, will be provided with *lustres*, or, as we call them, "chandeliers"—the English and French just transposing the signification to these two terms—with incandescent lamps, alternating with small arcs of 4 amperes, and incandescents of 24 volts and 6¾ amperes. The Salle des Fêtes, of nearly 3,000 sq. m. = 32,000 sq. ft. superficial area, will form the subject of a special scheme for which several electricians have submitted plans and estimates. The lighting will in all probability be effected by ten or twelve 12-ampere arcs, while groups of Edison and Swan, Victoria, and other incandescent lamps will be disposed in the space between the columns.

The interior of the King's Pavilion and the lateral colonades will be lighted by six to eight large arc lamps; while the back will be lighted by the reflection of two 3,000-c. lamps mounted in the roof framework. The balconies will be lighted by 30 to 50-c. Bernstein lamps, supplied by current from a distance in accordance with this inventor's system. The colonade connecting the central pavilion with the main building will stand out from the rest of the structure, owing to the white light distributed in profusion between the colours. This light will be supplied by Thomson-Houston lamps, 10m. = 33ft. apart, placed aloft and completely hidden from view. Four 3,200-c. arcs, with reflectors, furnished by MM. Bouckaert et Cie., will be placed at the bottom of the slope for throwing a pencil of white rays on the two pavilions in the foreground, so as to bring out the architectural features of the façades.

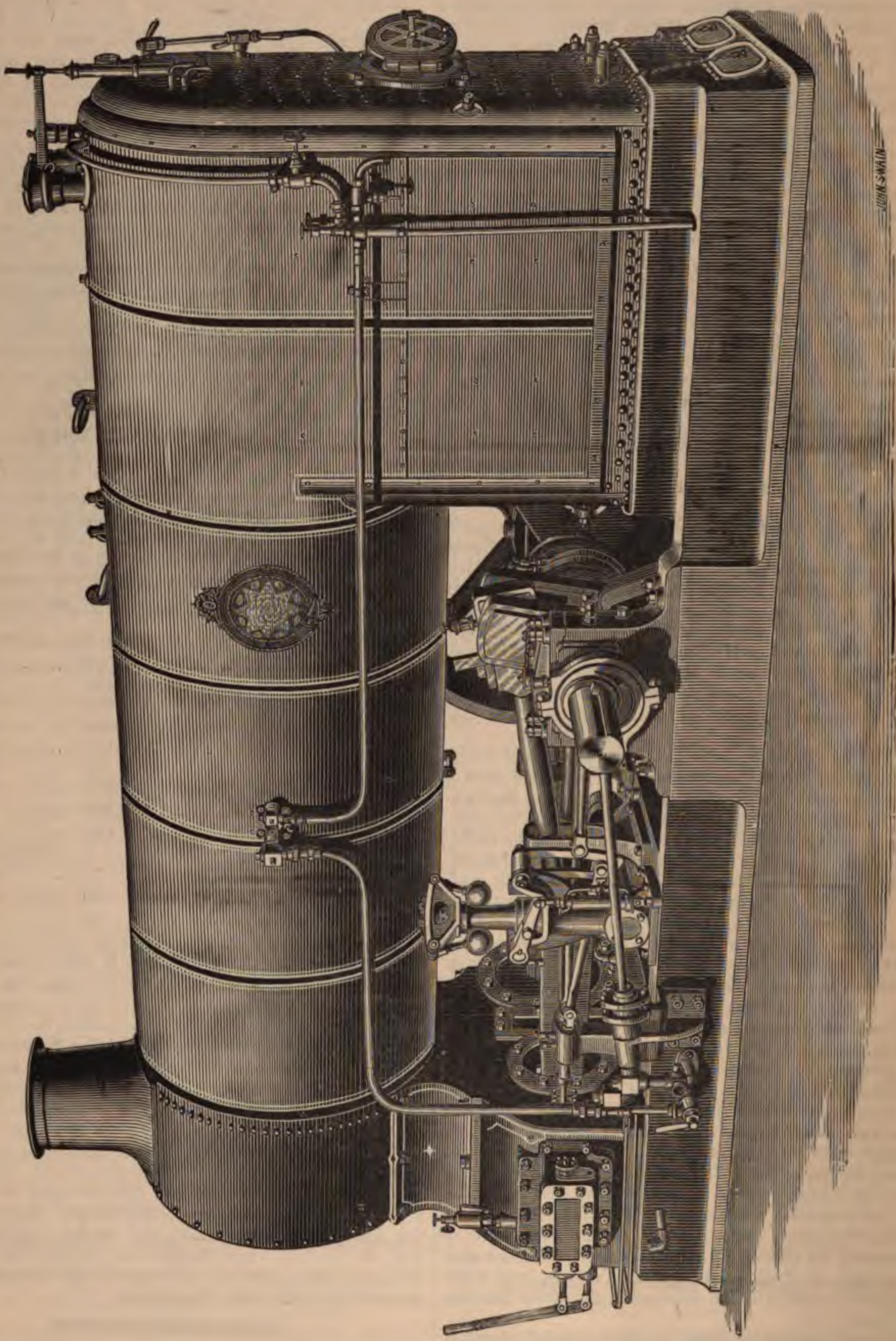
At the front end of the gardens two "hydro-electriferous pylons," on the Dulait system, 25m. = 82ft. high, and giving out a light of 5,000 candles each, will mark the main entrance. This installation, quite new of its kind, will greatly contribute to enhance the effect of the general illumination, which will extend the whole length of the Rue de la Loi. The annexes of the central hall will be lighted by 38 De Puyt, Dulait, and Piette et Krizik arcs, of an intensity varying from 350 to 900 candles for the right-hand annexe, and thirty 8-amp. Ganz arcs for that on the left hand of 2,400 sq. m. = 25,834 sq. ft. available area. This distribution of light, one lamp, 5m. = 16ft. high, for every 80 sq. m., or 861 sq. ft. of area, answers to 28 candle-metres of mean intensity—that is to say, a light about equal to that in the Machine Hall. Eight Thomson-Houston 2,000-c. arcs, 18m. = 59ft. high, will light up the garden in front of the annexes. Finally, several powerful lamps will be disposed along the avenue from the main entrance to the ornamental stone balustrade in front of the building.

All this aggregate of illumination will only require 350 h.-p., given by the motors in the Machine Hall, 150 h.-p. remaining available for lighting the façades of the pavilion erected in the centre of the semicircle. In fact, the motors in the machine hall will yield nearly 800 h.-p., of which 500 h.-p. are available for lighting purposes. The main shaft is 16 c.m. = 6¼in. in diameter, and will make 110 revolutions per minute, the countershaft for the dynamos making 250 revolutions. The yield of, and power required by, the various lamps, are estimated by the authorities as follows:—

Arcs.	Nom. c.p.	H.-P. required.
Piette and Krizig	3,500	1·50
" "	1,400	1·06
" "	1,200	0·85
Thomson-Houston	2,000	1·00
" "	1,400	0·75
Dulait	2,200	1·40
"	1,800	1·30
De Puyt	2,000	1·50
"	700	0·75
Incandescents.		Lamps per h.-p.
Bernstein	35	10·5
Victoria	16	10
Edison	16	10

The illumination of the fountains will be confided to Galloways or Sennett and Pieper, in which latter case the system will include a portion of the main walks of the garden. The two installations will be so combined as to work alternately, in order that the motive power necessary for the jets and the illumination of the fountains may be also utilised for contributing to the general illumination, for which purpose a 150 h.-p. engine will be erected in one of the wings of the Aquarium. The Aquarium, the Kursaal, and the Bierhalle will be lighted by Pieper, of Liége, while the English section will again receive its Manchester installation. Lastly, the gardens, plantations, and kiosques will be lighted by 25,000 gas jets arranged in garlands along the walks and in the shrubberies. MM. Gérard et Cie will probably undertake the electric lighting of the Rue de la Loi, their installation constituting the first industrial demonstration in favour of the adoption of the electric light for public illumination.

Society of Arts.—On the Saturday afternoons, March 10 and 17, at 3 o'clock, Prof. Lodge, F.R.S., will deliver two lectures, on the "Protection of Buildings from Lightning." Two other electrical papers are promised, but the dates are not yet fixed when they are to be read: one "On the Measurement of Electrical Currents," by Prof. G. Forbes, F.R.S.; and the other by Mr. R. E. Crompton, "On Electric Lighting from Central Stations."



MESSRS. ROBEY AND CO.'S COMPOUND "ROBEY" ENGINE.—(*For details see page 201.*)

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

THE CITY AND ELECTRIC LIGHTING.

This article is directly intended to convey information to members of the Corporation and others who, daily leading busy lives, are not familiar with the various developments of electrical practice, nor the present position of electric lighting. Avowedly, then, the object is to influence the authorities to come to a decision favourable to the employment of electricity for lighting our streets and houses. It is necessary, in the first place, to get rid of the idea that no more light is needed than is given at present by the gas lamps. Those who argue that the present light is sufficient cannot be familiar with the facts, nor could they be persuaded to advocate or support any change. It is probable that, like Charles Lamb, they come into the City late and go away early. No doubt such a course is perfectly satisfactory to those able to do it, but the workers are in a different position, and as the profits made in the warehouses, factories, and shops are directly due to the labours of the workers, it is not difficult to see that whatever conduces to a greater amount of work being done in a given time is a matter requiring careful consideration. No one will deny that more and better work is done under the beams of the midday sun than by any means of artificial lighting yet devised. It is admissible, therefore, to assume that the light which approximates most nearly to sunlight is better than any rival illuminant. Part and parcel of the work of the City is the transmission of goods and passengers from one point to another. Surely it will be granted that the better the light the greater the expedition in loading and unloading goods and in the pace of the street traffic. Without troubling further in this direction, it will be assumed that the more and the better the light distributed over the City the more is the economy of time and labour in the proceedings carried on therein. Thus, the questions presenting themselves somewhat forcibly to those who have to legislate for us as regards light are—Can we obtain more and better light at a reasonable cost for those who look to us to consider their interests? and, What kind of light can be so obtained? The question of cost is a little complex, as will be seen hereafter.

The problem before the City authorities at the present moment is whether it is better to replace gas by electricity, and upon their verdict much more depends than is at first sight seen. Taking the requirements of street lighting: there can be no two opinions as to the fact that with electricity you can get more light, and it is as emphatically proved that the light is a better light. It is ridiculous for those interested in gas to talk about the steadiness or unsteadiness of arc lamps as compared with the steadiness of street gas lamps. There is no such thing as steadiness in the latter, though there is in the former. When an arc lamp blinks it does so with a power of 800 or 2,000 candles;

when a gas lamp blinks it is with from 8 to 14 candles. The one is noticed and noticeable, the other has little or no influence upon the visibility of the darkness. With regard to atmospheric contamination, there is not much to be said in regard to street lighting one way or the other. If you burn coal under a boiler to generate steam to drive electric light machinery, you contaminate the air passing through the chimney shaft; with gas the contamination is more subdivided, that is all. It may be said that, if more light is required, it might easily be obtained by increasing the number of gas lamps or their brilliancy; by replacing, for example, each 14 c.-p. gas jet by one of 200 or 400 c.-p. No doubt that would in a measure get over the difficulty; but, unfortunately for the exponents of gas lighting, so far as economy is concerned, directly we come to "more light" electricity smites them hip and thigh. To compare the cost of an arc lamp of 800, 1,000, or 2,000 c.-p. nominal with a 16 c.-p. gas lamp is absurd; but the comparison is altogether in favour of the arc lamp when it is compared with an equivalent gas light.

Assuming then that more light is really required, it cannot be denied but that the electric light is better than gas, and we contend it is far and away cheaper. According to "Newbigging's Handbook for Gas Engineers," third edition, p. 209, the number of hours during which gas is burnt in a year, if lighted all night, is 4,327; if lighted at dark and extinguished at eleven o'clock the number is given as 1,808; if extinguished at twelve o'clock as 2,173. The worshippers of gas may, so far as we are concerned, say "more light" certainly, but extend the gas. Taking first 5 cubic feet per hour, as giving 16 candles, 250 cubic feet would give 800 candles; and 250 cubic feet would cost one-quarter of 2s. 6d. or 3s. or 4s., or whatever the price per 1,000 of gas, say 7½d, or, burning 1,808 hours per year, an annual cost of £56 10s. We have before us the actual cost of 200 c.-p. gas lamps in a midland manufacturing district given in the surveyor's annual report as varying from £13 16s. 8d. to £16 15s. 3d., say averaging £14, and this multiplied by 4 gives £56 as the cost of four 200 c.-p. gas lamps—that is 800 c.-p.—the equivalent of one arc lamp. This price depends greatly upon whether gas is burnt in one or more lamps to the candle-power mentioned. The amount £14 is for a 200 c.-p. lamp; the cost of the ordinary 14 or 16 c.-p. gas lamps is only £2 7s. 6d. for the year, so that if 200 c.-p. were obtained by increasing these lamps the cost would be between £29 and £30. The Brush Company offered the City a 2,000 c.-p. nominal arc lamp, which you may call if you like 800 c.-p. actual, for £26. Our contention then that electricity is cheaper than gas is, we think, justified. Increasing the light by increasing the consumption of gas means increasing the cost proportionately. If more light is wanted, the only loophole in favour of gas, so far as we can see, is that very little more light is needed, not twice as much as is now given, otherwise the offer of the Brush Company is exceedingly advantageous, in that they give at least ten times the light for twice the money now paid. It is stated that the electric light would be placed in the streets at a loss to the contractors. However that may be, is it not the case that gas is so placed, and that the gas companies, if they had only the street lighting to supply, could not supply it at the price now paid? It is useless to argue upon a portion of a scheme. The contractors take into consideration the whole lighting of the district, and doubtless are fully warranted in charging a much lower price for lighting, which is but part of a whole, than if that particular part had to be carried out alone.

There is one point that those in favour of gas might well discuss; in fact, it is the only point where they might score a point in their favour, though this is extremely doubtful. We have, however, no wish to cry up electricity merely for the sake of so doing. We believe not only that it is the best light for street lighting, but that it is the only light entirely suitable for that purpose. The point we refer to as worthy of argument is the distribution of the centres of light. The opinion of experts would incline to a larger number of lower candle-power lamps in such a city as London rather than a smaller number of greater candle-power. The great question to settle is the *minimum* light, reckoned in candle-power, required at any one point, although it would be as well to agree also upon a maximum. The two being given, the distance apart of the lights, neglecting the effect of reflection, is easily ascertained. Summarising, then, we hold: (1) More light is required; (2) Electricity is cheaper and better than gas; and (3) That care should be taken in the distribution of the centres of light radiation.

THE BILL OF THE UNITED TELEPHONE COMPANY.

The apathy of public bodies is proverbial; but at length London seems fairly roused to the evils of overhead wires, and petition after petition has been lodged against the Bill promoted by the United Telephone Company. This Company has few friends outside its own offices—except its shareholders. The reason is not far to seek, in its attempts to ride roughshod over the pet prejudices of the ordinary Englishman. Overhead wires are, like matter in the wrong place, objectionable only under particular conditions; and those conditions hold in London and other large towns. Overhead *v.* underground wires should be a matter of supreme indifference to the United Company. They know, we all know after a fashion, that the State sooner or later will buy over

the telephone systems, and will have to pay a larger price for underground than for equal overhead installations. The commercial heads of the various telephone companies want to make as much money as they can while their hands hold the reins, and—after then the deluge! Whatever system they adopt, the new brooms will find fault and sweep clean. If this should prove to be the case, any expenditure now carried out will be largely wasted; in that it will not have time to fructify to the extent it would do under ordinary circumstances.

Now for a *volte face*. We see no adequate reason for opposing the United Company's Bill, rather we see many reasons for heartily supporting it. Let it pass, let the work be carried out, let it interfere as much as possible with telegraphy; and the sooner will come the inevitable time when telegraphy and telephony will be systematically worked from one centre —the Postal Telegraph Department. Telephony is becoming more and more a necessity for commercial life. Its progress should not be hindered. If Jones of Dundee can talk with Smith of Glasgow, why should not Robinson of London talk with Brown of Birmingham? Surely there is no valid excuse for stopping an overhead wire going out countrywards, when we tolerate them by hundreds in crowded city streets. These wires are no more a nuisance in sparsely populated country places than are the telegraph wires.

CURRENT DISTRIBUTION OF THE NEAR FUTURE.

BY DR. LOUIS DUNCAN, JOHNS HOPKINS UNIVERSITY.

Outside of constant current systems, which may for the present be considered as occupying a permanent field apart from the others, the two rival systems of electrical distribution are the direct and alternating constant potential systems; the former using direct currents of low potential, the latter employing alternating currents of high potential, reduced to a lower potential at the points of consumption.

I have, on a former occasion, considered the efficiency of direct current generators under different conditions, and before taking up alternating current apparatus, I will consider briefly the relative value of the two systems.

For lighting alone, leaving out the possibility of the use of storage batteries, and considering solely the economy of distribution, the alternating system presents a number of advantages where we wish to supply an extended area with light. These advantages are well known. In the first place, the flexibility of the system is greater; and, in the second place, the cost of conductors is very much less. It is in this last item that the system possesses the greatest advantage, and it would seem that it is undoubtedly better than either the parallel or multiple series systems for lighting extended areas, where the lights are more or less scattered.

There are two comparative disadvantages, however, in the system. No alternating current motor has yet been invented that will work practically, and, even provided storage batteries are improved so as to allow of their extended use, the system cannot economically profit by the storage of electricity. As to the first disadvantage, I think that it will, in time, be overcome. The problem is a perfectly definite one, as there are no underlying impossibilities in the working of such a motor, and I have strong hopes that in the next year or so alternating current motors will be working as successfully and economically as continuous current motors are to-day

But if I believe in the future of alternating motors, I also believe in the future of storage batteries; and when these can be economically used, the greatest comparative advantages of the alternating system are lost. The flexibility of the direct system will then be as great as that of its rival, while it will gain the great advantage of storage, allowing a station to supply two or three times the energy with no increase of plant or complexity excepting that due to the battery itself.

The plan to be adopted would doubtless be to establish sub-stations containing the batteries and regulating apparatus, each of these stations supplying an area determined by the circumstances of the case, with an attendant in charge of one or more such stations. Such a system would allow all the uses to which electricity can be applied, and under simple and favourable conditions.

Even under present conditions, if the company manufacturing the distributing apparatus had the right to manufacture storage cells and supply them at a slight advance over cost price, and afterwards renew them when necessary, I believe the storage system could be economically applied in some cases. For example, the 1 h.-p. cell of a well-known company probably costs something like 7 dols. to make, taking lead at 5 cents per pound, and red lead and litharge at 6. For renewal we should allow, perhaps, one complete set of positive plates and 15 per cent. depreciation on the rest of the cell. This, subtracting the value of the old positives, would give not over 2·50dols. a year for depreciation. If we take these figures we could, I think, work out a profit in some cases. It is the best that can be claimed for storage at present, unless I have over-estimated the repairs. It is needless to say, however, that these prices are not those which rule in the market at present.

I have seen lately, in an English journal, an article by Mr. Rankin Kennedy, in which he wishes to show that the alternating system would profit by the success of the storage battery. He proposes to have the cells at the central station, to charge them during the day, and, when extra power is required, to use them to drive the motor of a motor-alternating-dynamo apparatus which will feed into the main lines. I fail to see any particular advantage offered by this plan; certainly no advantage comparable with that obtained by the direct system.

The advantage of storage batteries used in connection with a system of distribution, apart from any increase in the facilities for distribution, is this: It allows the plant to be utilised the entire twenty-four hours of the day, instead of only a part of that period. Now, the plan of Mr. Kennedy certainly does allow a part of the original plant to work the whole time, namely, the engines and boilers; but the dynamos are idle, and the investment has been increased by the purchase of the motor-dynamo, *i.e.*, the machines he proposes to use. Of course, the motor part of the new arrangement can be used to charge the batteries. However, this fact remains, that the capacity of the station is never greater than that of the dynamos that are running. It is a question of economy whether the increased number of dynamos shall be driven by increasing the steam plant or letting the steam plant remain the same, by purchasing a storage battery and motors equal to the additional power required, and wasting afterwards the energy lost in the three conversions necessary, a constant loss of 30 or 40 per cent. (supposing the battery has 80 per cent. efficiency). I think that in most cases it would be preferable to enlarge the steam plant.

I do not know what the arrangement of converters would be in the alternating systems in cases where the wires were necessarily underground. I suppose the primaries and secondaries would be connected as in the overhead lines, a number of the latter to the same circuit. This arrangement is, of course, greatly preferable to using a single converter for each house, since in the latter case the converter would have to be of the maximum capacity needed, while the average energy taken from it for a month would not be more than, say, one-twentieth of this. Using a single circuit for a number of houses partly obviates this, although I might show that the average efficiency of such a system for the twenty-four hours is considerably less than the maximum efficiency of any converter.

To sum up briefly the views given above of the relative values of the alternating and direct systems of distribution,

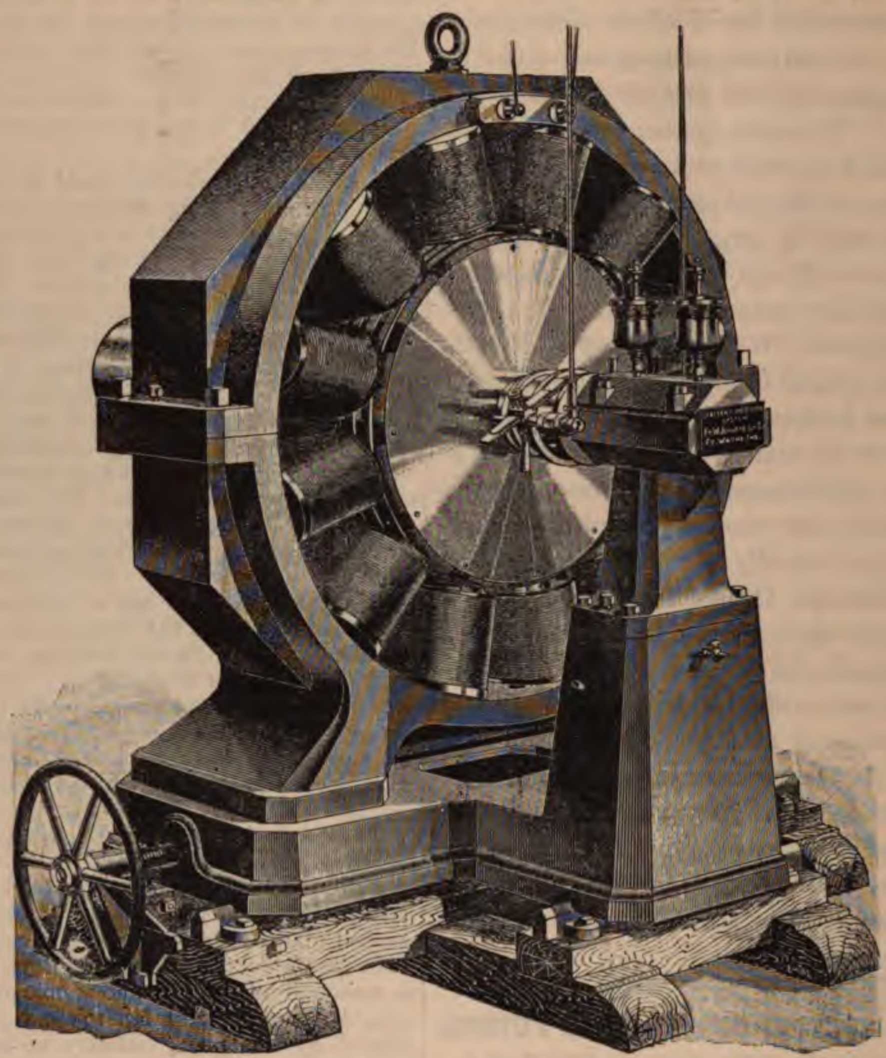

Fig. 1.—Slattery Generator.

I think that at present the latter has many advantages in densely populated areas, especially if power can be distributed as well as light; while the former is in a better position to distribute light where the population is more scattered. But it is very evident that a combination of the two systems would be vastly better than either alone, in almost any supposable case.

Indeed, when one considers the great advantage that a local lighting company, utilizing any system or any part of a system it might need, would have over companies, as most of them are at present, using only one system and only able to do one kind of work, it encourages us to think that even if no new discoveries were made, but those we have already were properly combined, the cost of domestic lighting by electricity would be less than that of gas.—*Electrical World.*

THE SLATTERY ALTERNATING DYNAMO.

The dynamos herewith illustrated are from designs of Mr. M. Slattery, assisted by Mr. R. Mackie, and constructed by the Fort Wayne Jenney Electric Light Company. According to our American contemporaries, the *Western Electrician* and the *Electrical World*, the Lontin type was selected after competitive trials. The machines have been designed for use with transformers. The machine illustrated is intended to supply current for 1,800 16 c.p. lamps of 50 volts, and has 35lb. of copper on the armature. The exciter is also shown. The transformer—or as our friends across the Atlantic call it—the converter is constructed as follows:—

The copper wire is wound upon a core consisting of insulated iron plates, rectangular in form, divided centrally, and placed back to back, previously having had a sufficient portion of the centre cut out, in which spac coil referred to is wound. The magnetic circuit is closed around the sides of this coil by the other half of rectangular plate. The induction in this converter is e

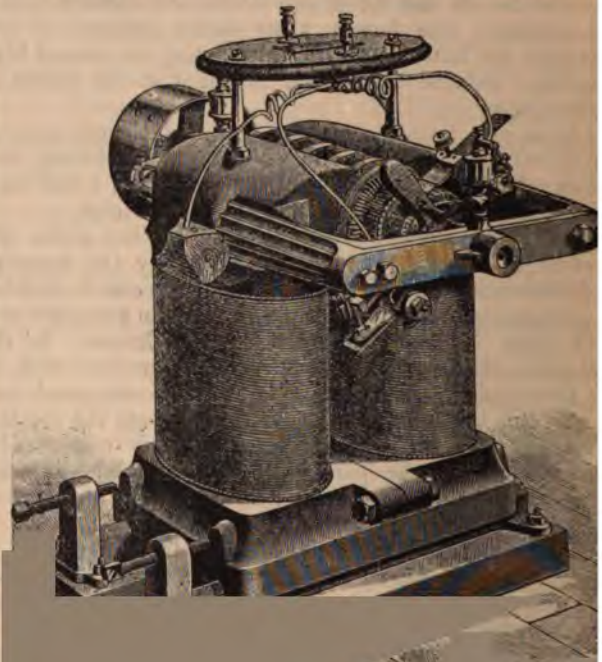

Fig. 2.—Slattery Exciter.

to a volt per five inches of wire, the ratio of conver twenty to one, and there are nearly two pounds of iron

secondary ampere capacity. The working pressure of the system is 1,000 volts at the terminals of the primary coil and 50 volts at the terminals of the secondary coil.

ON THE POSITION AND PROSPECTS OF ELECTRICITY AS APPLIED TO ENGINEERING.*

BY MR. WILLIAM GEIPEL, OF EDINBURGH.

(Concluded from page 185.)

In a colliery at Zankeroda, near Dresden, power is generated above ground by a vertical engine having 10-inch cylinder with 8-inch stroke, which drives a Siemens dynamo. The current is led to the shaft, which is about 60 yards distant, by two bare copper wires; then down the shaft to a depth of 120 fathoms by well insulated conductors, to the ⊥ irons, which run along the roof of the wagon way and form the contact rails, The current is picked off these rails by sliding contact-pieces fixed to the locomotive, and is led to a switch, which can turn the full current either through the motor or first through reducing resistances and then to the motor. A controlling switch with a seat for the driver is placed at both ends of the locomotive, so that perfect control of the speed and of the starting and stopping of the motor is provided. The length of the line is about 700 yards, and the gauge is 22½in. A train consists of about 15 tubs, each carrying 10cwt. of coal; and the locomotive weighs rather over 30cwt. The journey takes from three to five minutes, the speed varying from five to seven miles per hour. The plant cost a little over £800, including steam engine, dynamo, motor, locomotive car, conductors, and accessories; it has been working successfully since 1882, and was supplied by Messrs. Siemens and Halske, by whom several other mines in Germany have since been similarly furnished. The working cost of hauling 660 tubs, per day of 16 hours, is given by Mr. Rowan, as follows:—

	s.	d.	s.	d.
Driver's wages	5	3		
Steam	2	3		
Engine-driver at surface	3	1½		
Lubricating, &c	1	1½		
			11	9
Interest and depreciation at 15 per cent. per year of 300 working days			8	1½
Total working cost per day			19	10½

For the output of 660 tubs or 330 tons per day this amounts to only about three farthings per ton.

Telpherage.—The plan of transporting material in skips on overhead wire ropes by means of electricity, introduced under this name by the late Professor Fleeming Jenkin, of Edinburgh, has not so great a field for its use in this country as it may have in less populous regions, because our roads are good, and railways generally near at hand, and we have abundance of water carriage. But in places where material has to be conveyed across hilly districts or over bad roads to the railway or water, it will be found more useful. It has been employed with considerable success for the past two years at Glynde, near Lewes, for transporting clay to the railway over a distance of 1,600 yards; 270 tons are carried weekly at 7½d. per ton. In our larger cities a modification of this plan might advantageously be applied to alleviate the heavy street traffic. In the place of wire ropes, stiff girders might be used, the cars being suspended from wheels running along a rail or rails fixed on the girder. Such a railway would be economically constructed, in comparison at least with the expense of constructing an underground railway; and it would not have any great effect in obstructing the light from the streets, as is the case with elevated railroads for steam locomotives.

A general idea of the present position of electric locomotion in Europe and America is furnished by Table IV., which is an abbreviation of one compiled in May, 1887, by Mr. T. C. Martin, President of the American Institute of Electrical Engineers.

* A paper read before the Institution of Mechanical Engineers, February 2, 1888.

TABLE IV.—*Electric Railways in Europe and America.*

Place, and Mode and of Working.		Length of line.	Rolling Stock.	Cost of working.
EUROPE.	*	Miles.		Pence.
Lichterfelde, Berlin	R	1·5	2 cars	
Brighton	R	1	2 cars	1·92d. per car mile.
Moedling-Hinterbruchl	O	2·8	12 cars	3·42d. per car mile.
Frankfort-Offenbach	O	4·1	14 cars	3·83d. per car mile.
Zankeroda Colliery	O	0·45	1 locom. 16 wagons	0·77d. per ton.
Hohenzollern Mine	O	0·47	1 locom. 15 wagons	0·50d. per ton.
Portrush	T	6	4 cars	2½d. per car mile.
Bessbrook and Newry	T	3	8 cars	4d. per train mile.
Blackpool	U	2	10 cars	less than 4d. per car mile
Brussels	S	...	5 cars	
Hamburg	S	...	2 cars	
AMERICA.				
Baltimore, Md.	T and O	2	6 cars	16s. 8d. per car per day
Los Angeles, California	O	3	8 cars	
Port Huron, Michigan	O	4	8 cars	
Windsor, Canada	O	2	2 cars	16s. 8d. per day for power
Highland Park, Detroit	T	3½	2 cars	3s. 2½d. per day for fuel
Dix Road, Detroit, Mich.	O	1¾	4 cars	
Appleton, Wisconsin	O	4½	8 cars	
Scranton, Pennsylvannia	O	3¼	3 cars	
Denver, Colorado	U	3½	7 cars	6s. 2d. per day for fuel
Montgomery, Alabama	O	11	18 cars	50 per cent. less than horse and mule traction
Kansas City, Missouri		...	...	
Orange, New Jersey	O	½	1 car	
Boston, Mass. (short line in sugar refinery)	O	...	1 locom. 3 cars	

* O=Overhead conductor. R=ordinary Rails. S=Storage batteries. T=Third rail. U=Underground conduit.

III.—Electric Lighting.

Of the four branches of electric engineering dealt with in this paper, electric lighting is the one which, up to the present, has received most attention, called forth the largest outlay of capital, and produced the most beneficial results, if not to so great extent in this as in other countries.

Artificial illumination may be considered in the three aspects of comfort, convenience, and economy.

As regards *comfort*, electric lighting proves itself superior to all other methods of illumination. For indoor lighting, the incandescent light may be utilised and toned down to suit almost any requirement. It may be brought near to any object requiring illumination, without occasioning the least inconvenience from heat or dazzle; or it may be far removed in the ceilings or cornices, without risk of fire or of injury to the decoration. In short, it can be used in any position or for any purposes of illumination for which gas, oil, or candles are available, and for a great many for which they are not available. For outside illumination and large enclosures the arc light gives a brilliancy and cheerfulness altogether unattainable by any reasonable expenditure of gas or oil.

The *convenience* of the electric light has caused it to be highly appreciated, when it is found that by the mere pressing of a button a light is instantly obtained, which can be shaded over in any manner, without danger of setting fire to the fabric forming the shade. It also does away with the constant cleaning of globes or trimming of lamps.

In respect of *economy*, the electric light does not as yet hold out the same decided advantages that it does in the other two respects just considered. In incandescent lighting, the cost of distribution is still heavy, though by increasing the electromotive force and the efficiency of lamps it is being much reduced. In arc lighting, the difficulty of subdividing and of reducing the amount of light given by one arc-lamp renders it expensive for general out-door street illumination, as compared with the present low prices of gas and oil. For the lighting of main streets and railway stations, or other places where a concentrated light is required, the arc light is beyond question far cheaper than gas; and its cost per candle-power is but a very small fraction of that of gas. As the use of electric lighting extends, the cost of working becomes reduced; installations which four years ago cost 4d. per arc lamp per hour are now costing only 2d. The chief saving has been in the items of carbons and attendance, though the increased efficiency and durability

TABLE V.—ELECTRIC CONDUCTORS.—*Sectional Area, Cost, and Potential Fall.*

Cost of conductors.	£100 per ton = 10·71d. per lb.			£150 per ton = 16·07d. per lb.			£200 per ton = 21·43d. per lb.			£250 per ton = 26·79d. per lb.		
Cost per year per electrical h.-p.	Area per 100 amps.	Cost per 100yds.	Potential fall per 100yds.	Area per 100 amps.	Cost per 100yds.	Potential fall per 100yds.	Area per 100 amps.	Cost per 100yds.	Potential fall per 100yds.	Area per 100 amps.	Cost per 100yds.	Potential fall per 100yds.
£	Sq. in.	£	Volt.	Sq. in.	£	Volts.	Sq. in.	£	Volts.	Sq. in.	£	Volts.
½	0·04576	2·378	5·3231	0·03736	2·912	6·5194	0·03235	3·362	7·5279	0·02894	3·759	8·4165
1	0·06471	3·362	3·7640	0·05283	4·118	4·6099	0·04576	4·755	5·3231	0·04093	5·316	5·9514
10	0·20463	10·633	1·1903	0·16708	13·023	1·4578	0·14470	15·037	1·6833	0·12942	16·812	1·8820
20	0·28939	15·037	0·8417	0·23629	18·417	1·0308	0·20463	21·266	1·1903	0·18303	23·776	1·3308
30	0·35443	18·417	0·6872	0·28939	22·556	0·8417	0·25062	26·046	0·9718	0·22416	29·120	1·0866
40	0·40926	21 266	0·5951	0·33416	26·046	0·7289	0·28939	30·075	0·8417	0·25884	33·625	0·9410

of the apparatus have also greatly contributed to the reduction: four years ago 11mm. or 0·43in. hard carbons cost 4d. per foot; they can now be obtained for 1¼d. per foot, or less than one-third.

The following figures supplied by the North British Railway respecting the actual cost of working their electric lights at the Waverley Station, Edinburgh, are interesting as showing how much cheaper it is becoming. The installation is worked by their own staff, and consists now of forty Brush arc lamps, supplied with a current of 10 amperes by a No. 8 Brush dynamo, which is driven by a semi-fixed engine.

July to December, 1884, thirty-three arc lamps, 41,884 lamp-hours.

	£	s.	d.
Wages	£165	13	9
Repairs	47	2	6
Carbons	125	15	11
Coal	65	19	11
Oil, stores, &c.	27	15	0
Interest and depreciation at 10 per cent.	52	2	2
Equal to 2·77 pence per lamp-hour	£484	9	3

July to December, 1886, thirty-nine arc lamps, 55,068 lamp-hours.

	£	s.	d.
Wages	£195	17	6
Repairs	78	9	6
Carbons	62	17	3
Coal	23	14	1
Oil, stores, &c.	8	15	2
Interest and depreciation	41	10	6
Equal to 1·79 penny per lamp-hour	£411	4	0

In conjunction with these arc lamps they are running 148 Brush Victoria incandescent lamps, distributed in the refreshment and waiting rooms, and throughout the whole of the suburban station. For these the total number of lamp-hours for the half-year was 171,251, and the cost was £83 9s. 9d., including all contingencies, equal to 0·12 penny per lamp-hour. There were 113 lamps renewed, which shows an average life per lamp of 1,515 hours.

Local Conditions.—The cost of incandescent lighting is especially variable, and affected by the local conditions of the installation. The chief of these are (*a*) the average number of hours of lighting each lamp, and (*b*) the average distance of the lamps from the generating station. Where the conditions are favourable, incandescent lighting can already compete with gas; and in a number of installations which have been superintended by the author a large saving is being effected. The following figures, kindly supplied by Messrs. George Jager and Son, show that the yearly cost of lighting their sugar refinery at Leith has been reduced from £347 with gas, to £204 with incandescent lamps:—

Previous average cost of gas lighting per annum	£332	13	4			
Part of plumber's time	15	0	0			
				£347	13	4

Cost of Electric Light, May, 1886, to May, 1887.

Lamp renewals	£46	9	8			
Oil, waste, sundries	17	5	0			
Coal at 3lb. per h.-p. per hour, 40 tons at 6s.	12	0	0			
Repairs, including men's time attending dynamo	36	5	3			
Depreciation at 10 per cent.	33	16	0			
Gas consumed on Sundays, and when engine is standing	58	4	5			
				204	0	4
Saving per annum by electric lighting				£143	13	0

The average life of the lamps is about 1,400 hours each. The installation consists of 180 Brush Victoria lamps of 17 and 10 candle-power, supplied by a self-regulating Victoria dynamo, which is driven off the shaft that drives the centrifugal drying machines. The dynamo has been running night and day since it was started two years ago, without failure; it is started on the Monday morning, and runs continuously without stoppage till the following Saturday afternoon.

In the United States there is hardly a city or town of 20,000 inhabitants which has not a central station for arc or incandescent lamps; and many towns of 3,000 to 4,000 are supporting them also. On the Continent large central stations for electric lighting are already in operation in competition with gas; but there the price of gas is generally two or three times what it is in this country.

If the power is to be generated by dynamos and used direct, the cost of distribution on a large scale will probably never be reduced as low as with the existing gas supply; seeing that an efficiency of 95 per cent. can now be obtained with the dynamo, and that steam engines are not likely to be materially improved. It is therefore in the lamps that improvement is to be looked for, by making them with a higher resistance and greater efficiency.

The accompanying Table V., which is an abbreviation of one previously constructed by the author, may be interesting here as showing how the economical sectional area of conductor, and the economical loss of potential vary for the different conditions of amounts lost in interest and depreciation on the conductors, and in horse-power wasted in overcoming the resistance of the conductors. The question of conductors is one which must be left to a very great extent at the discretion of the engineer, in view of what are likely to be the requirements of each individual case; but when the conditions have been settled Table V. is useful in showing at a glance the size and cost of the conductor and the ensuing loss of potential.

Transformers.—These are at present receiving a large amount of attention. By their means small high-tension currents of electricity, sent from a distant generating station along a small conductor with a comparatively small percentage of loss, can then be converted into large low-tension currents for the supply of ordinary incandescent lamps. In some arrangements of these transformers the loss in conversion is not more than 5 per cent. Unfortunately the alternating system, which has thus far been adopted, cannot be used with satisfaction for driving motors doing practical work, or for charging storage batteries. The continuous-current transformer has certainly the advantage in respect to the supply of power and to the charging of storage batteries; but it is a question whether the disadvantage of having to keep it continually in motion will enable it in town lighting to compete with the alternate-current transformer. The latter is employed in the Grosvenor Gallery central station in London. Some idea of its importance may be formed from the fact that the Westinghouse Co. have already in America over 100,000 lamps at work on this system, although it is not yet so much as two years since they adopted it. Notwithstanding that the use of transformers enables a great saving in copper to be effected, more especially where the lamps are scattered, as in suburban districts, yet it is to be remembered that the insulation of underground conductors forms a very important item in their total cost. The installations already at work are all worked with overhead conductors, with the one exception at Eastbourne; so far as the author is aware, there are no practical data to establish the general applicability of the transformer system for the lighting of large

ckly populated towns where underground conductors one be tolerated. The loss owing to induction will ly greater with underground conductors however y installed.

ndary batteries charged in series by a high-tension , and discharged in parallel circuit, have been tried nentally; but their practical application is not known uthor. At the same time, now that transformers oming more used, strenuous efforts are being made duce this system of secondary batteries; and if it e be demonstrated to be economical, there can be oubt that it would have a large field of application. at merit is, of course, the reduction of risk of the iling.

hould be borne in mind by electric-light com- that the supply of incandescent lamps is not to r only source of revenue; but, as already pointed e supply of current should be of such a nature may be employed for as many purposes as pos- By the use of efficient boilers and engines and y constructed continuous current dynamos, a central can be so constructed as to be no nuisance whatever, d proper precaution be taken in selecting the site. e towns it will not be necessary to extend the con- very far before a demand will be met with sufficient upying an engine large enough to be economical. a certain size the cost of working a steam engine s practically constant for any increase in size; so stead of working from one large central station over large area, it is found better to work from smaller s over smaller areas. The cost of attendance will be increased to only a small extent, because one nnot fire more than two boilers; therefore when oilers are required it is preferable to work them at station with another fireman. At Leamington an ve central station is now at work, and the cost of lertaking is about £30,000. The Bradford Corpora- ve recently voted a sum of £15,000 for erecting a station in their town. Both of these are instances ct supply, without transformers or secondary bat-

IV.—Electric Metallurgy.

branch of electrical engineering bids fair to become y of the highest interest to engineers. The electro- l separation of ores on a commercial scale by the furnace has but recently been put to the test, in obtaining aluminium from corundum, its richest Sir William Siemens first turned his attention to the , but his death occurred before he had perfected his on. It was taken up by Messrs. Cowles, who, with istance of Professor Mabery, have devised a furnace, h by the passage of powerful currents the refractory uccessfully reduced. The furnace is built of fire- and lined with powdered charcoal to withstand the heat; it is in the form of a box, 5ft. long, 12in. nd 15in. deep. Current is conducted through the nd into the ore by means of a number of carbon rods, ameter and from 2ft. to 3ft. long. The positive and e carbons are introduced from opposite ends, and meet in the centre. The ore, mixed with charcoal anulated copper, is put in so as completely to d and cover the carbon. The furnace thus charged d with a layer of charcoal and a lid lined with fire- without the protection of some such refractory l as charcoal the intense heat causes the firebricks When the furnace is ready, the current with an motive force of 50 volts is turned on, and is gradually ed up to some thousands of amperes. In a few s the metal is melted around the electrodes; and are then moved further apart, until the current through the entire charge, and the whole is in a condition; the corundum becomes gradually ised, the aluminium combining with the copper, the oxygen with the carbon escapes as carbonic about five hours suffice to complete the reduction. t is supplied by large Brush dynamos, one of which ecially constructed for the work, and is capable of out 300,000 watts, or over 400 electrical h.-p. Its is nearly 10 tons; 5,424lbs. of copper are wound field magnets, while the armature has 825lbs. of copper on it. Works already in operation at Lockport, U.S., have a capacity of 6,000lbs. per day; and the cost of the aluminium-bronze so made is expected to be less than 1s. 8d. per lb., while Mr. Cowles anticipates the price being reduced to 8d. per lb. Works have also been started at Stoke-on-Trent, where a 500 h.-p. dynamo has been fixed for generating the current; the potential is 60 volts.

Another electric furnace has been devised by Dr. Kleiner, of Zurich, in which cryolite, a double fluoride of sodium and aluminium, is similarly treated.

When it is remembered that the metal aluminium, in addition to many other good qualities, possesses great strength with only one-third the weight of iron, the importance of obtaining it at a reasonable cost will be readily appreciated; it would undoubtedly cause a great revolution in engineering construction.

The process of welding by electricity, as introduced by Prof. Elihu Thomson, is similarly based upon the passage of a powerful current between two electrodes. In this case the two pieces of metal to be welded form the electrodes: they are brought together into close contact, and as soon as the current is sent through the joint its resistance causes intense heat until the weld is perfectly completed. The process is almost instantaneous, and the heating occurs only at the joint; tempered steel can be thus welded without in the least affecting its hardness.

Another plan of electric welding has been introduced at St. Petersburg by Dr. Bernardo, in which the heat necessary for fusion is caused by an arc. The current is conducted to the weld by means of a carbon rod, which is connected by a flexible cable with the positive terminal of a dynamo or battery, while the metal to be welded is connected with the negative terminal. The action of the arc set up by the flow of current from the carbon to the metal may be likened to that of the blow-pipe flame, except that the heating is more intense and sudden, and is therefore more local. The reducing action brought to bear on the metal keeps it clean and unoxidised.

PORTABLE READING LAMP.

Railway travellers not infrequently, when they desire to read, supplement the miserable light usually provided by the companies with lamps and candles, that they may be able to read with some degree of comfort. A few luxurious individuals in the earlier days of electric lighting with accumulators, astonished their fellow travellers by producing a small battery and electric lamp to assist their reading. We remember Mr. W. H. Preece showing such a lamp, which, hanging by a hook from his buttonhole, enabled him

Portable Reading Lamp.

to read while his fellow passengers were muttering anathemas against the oil-lamp at the roof of the carriage. The manufacture of such lamps is now forming a recognised branch of Messrs. Woodhouse and Rawson's work, and we herewith illustrate the latest form of such lamps as made by them. As will be seen the lamp is attached to a flexible cord, so as to enable it to be placed in any convenient position. The secondary battery used with this lamp weighs about one and a half pounds, and can be carried in the pocket without difficulty.

CORRESPONDENCE.

THE BRUSH COMPANY'S PROPOSAL.

To the Editor of The Electrical Engineer.

Sir,—Referring to the notice in your issue of last Saturday anent the proposal of the Anglo-American Brush Company to light a certain area of the City of London, will you kindly allow me to express the feelings of regret with which I learned that the Commissioners of Sewers had again rejected the proposal, owing, apparently, to the rather ungallant interference at the eleventh hour on the part of the Maxim-Weston Company.

For some time past I, as one deeply interested in the introduction of the electric light to Dublin, have been watching with no little anxiety the progress of this proposal, believing that its final acceptance would be the means of imparting a considerable impetus to the electrical industry.

It is much to be regretted that those praiseworthy negotiations (now extending, I believe, over some years) to undertake an interesting and highly important work on legitimate and properly constructed commercial basis should be as it were invaded by the overtures of a practically untried company, whose electrical apparatus has not as yet come very conspicuously before the public.

It would have been very much more conducive to the interests of the electric light generally if Mr. Watts' Company had gracefully stood aside and allowed the work in question to be carried out without obstruction by those who had spent so much time and energy in working the matter up to its present position.

I believe that until some such elaborate scheme as that proposed is in practical operation in London, we in the provinces shall have to wait a long time before our desire to see the new illuminant installed in our streets and houses is gratified.

Therefore it is that I earnestly hope the City Commissioners will reconsider their decision of Tuesday last, and find it to their advantage to come to terms without delay for a grand scheme of electric lighting on sound commercial basis.—Yours, &c.,

Angelo Fahie,

Mem. Society Telegraph Engineers and Electricians.

10, Leinster-street, Dublin, 28th Feb., 1888.

THE PENTANE STANDARD LAMP.

We have recently had occasion to draw attention to the Pentane standard lamp, devised by Mr. A. Vernon Harcourt, and made by the Woodhouse and Rawson Electric Manufacturing Company.

The excellent work done by this lamp has been shown by Mr. W. T. Dibdin in his report upon standards of light to the Metropolitan Board of Works, in which the lamp stood at the head of all the standards tested, and yielded the exceedingly good average of 97 per cent. of tests within 1 per cent. of the mean value, a result we take it never before reached by any standard tested under similar conditions.

We understand that Mr. Harcourt's aim in devising this lamp was to produce a portable and self-contained instrument, dispensing with some of the more bulky apparatus employed in his well-known Pentane standard.

Notwithstanding the excellent results attained by this lamp, Mr. Harcourt believed that he could construct a lamp on a somewhat different principle which would be equally exact and more easily managed. This new form of lamp he exhibited before the Physical Section of the British Association at its meeting in Manchester last year. The new lamp has been put into the hands of the makers of the former lamp, and we append a sketch of it. Instead of burning a mixture of air and pentane, it burns pentane vapour only, and though unprovided with any glass chimney round the flame, burns steadily even when exposed to moderate draughts. At the same time, the important condition that the colour of the flame produced by the direct combustion of the rich pentane vapour should be as white as possible is accomplished, as will be shown by the same apparatus.

It will be seen from our sketch that the lamp takes a form somewhat similar to an ordinary spirit lamp with an additional metal chimney above. The metal chimney, by producing a strong upward draught, serves a twofold purpose—(1) the flame is kept exceedingly steady, and (2) the temperature of combustion is raised and a whiter light is produced.

It will also be seen that a wick is employed, which would be a distinct disadvantage were it used, as wicks generally are, within the flame or close to the point of combustion of the vapour; but in this case the wick remains at a distance of 2in. or 3in. from the point of ignition, and serves only to convey the liquid pentane by capillary action to a part of the tube in which it is volatilised by the warmth conducted downwards from the flame. The wick, it will be observed, is enclosed in a tube, in which it fits comfortably, and which is open at the upper and lower ends. This tube is jacketed by a larger tube, to which it is attached by flat plates. This jacketing serves to produce a steady temperature of the liquid and vapour contained within it, the vapour burning as it is produced at the upper extremity of the tube. These two tubes are further jacketed by another larger one, the upper portion of which is contracted into a smaller tube, which is of the same size as the lower portion of the chimney.

The chimney is itself enlarged in its upper portion, and is attached by two metal bands to the exterior of the larger part of the lower tube. The bands are so shaped as to be at some distance from the flame, and by means of slots cut in their lower

The Pentane Standard Lamp.

portion the chimney of the lamp can be moved up and down within the necessary limits. The lower tube is removable, and is attached to a gallery (solidly fastened to the base of the lamp) by a bayonet joint.

The action of the lamp is as follows:—On removing the lower tube and warming the inner tubes the pentane vapour rises from the opening in the small tube and can there be lighted. On putting on again the large tube with the chimney attached the flame rises above the top of the edge of the lower tube, and by slightly raising the wick the top of it passes into the chimney. In this chimney two narrow slots of 10mm. high are cut diametrically opposite to each other, so that the tip of the flame may be seen through either of them. When the movable chimney is set at a definite height above the upper edge of the lower tube, and the flame is raised so that the tip is seen to be somewhere between the upper and lower limits of the slots, the central portion of the flame appearing between the upper edge of the lower tube and the lower edge of the chimney gives a definite quantity of light.

It is well known that the light emitted from the centre of a flame is little affected by considerable variations in the height of the flame. With the flame of this lamp Mr. Harcourt has found experimentally what part is of the most constant brightness, and what variation in the height of the flame may be made

without affecting measurably the brightness of this part. The actual position of the interval between the lower tube and the chimney, and the length of the slot opposite to any part of which the tip of the flame may be, are the outcome of these experiments. Mr. Harcourt has found, and his results have been confirmed by subsequent experiments at the maker's factory, what portions of the flame must be selected to give a light of 1 candle or $1\frac{1}{2}$, or $\frac{1}{2}$ a candle, as may be preferred.

Of course, any intermediate values can also be obtained by setting the chimney at various heights above the lower tube, and thus altering the amount of light visible between the upper and lower tubes.

The method for accurately settling the height of the chimney is both ingenious and simple; in fact it forms one of the most attractive features of the lamp. Small gauges of accurate height and exactly fitting the outside diameter of the upper and lower tubes are inserted between them; the chimney is lowered until it rests firmly and securely upon the gauge; it is then screwed tightly to the lower cylinder by means of set screws, and the gauge is withdrawn horizontally, leaving, of course, a distance between the two tubes exactly equal to its height. In the case of the gauge requisite to obtain a half-candle it is found necessary to add a small collar upon the lower tube so as to ensure a portion of the flame being used which will remain perfectly constant, even though the height of the flame vary within the prescribed limits. This variation of the height of the flame is found to be exceedingly small after the lamp has been alight for ten minutes or a quarter of an hour and the inner tube has reached a constant temperature, the constancy of which temperature is greatly increased by the method of double jacketing which has been employed.

In order to make the instrument thoroughly accurate, as well as convenient, the inventor has added a base with levelling screws and a simple and efficient method of levelling the lamp, in addition to which he has provided a small piece of glass suitably fixed to reflect the upper portion of the flame visible through the slots, so that its position with regard to the slots may be verified at any time by an observer towards whom the face of the lamp is turned.

The colour of the light is such as to make photometry of ordinary gas lights exceedingly easy; in fact, it is nearly the same as that of the pentane flame, against which no such objections have ever been made on the ground of colour as have been made in the case of the well-known Amyl Acetate lamp.

The lamp has been well tested in exposed positions, and has stood the tests remarkably well, the flame resembling a luminous pencil more nearly than an ordinary flame.

Mr. Harcourt pointed out before the Physical Section of the British Association that, owing to the employment of an upper and lower cut-off, it is impossible to measure distances from any portion of the flame or any part in point of it, so that the law of variation of light according to the inverse square of the distance should exactly hold; but he stated that if distances are measured from a point midway between the axis of the flame and the face of the cut-off, the errors from this cause are perfectly negligible at all distances not less than 10in.; and he has ensured this point being easily found by making the metal bands which unite the chimney and lower tube of half the width of the cut-off tube, and by cutting two slots in these bands into which a metal plate can be slipped. The lamp can thus be brought into its true position either by setting the edges of the bands, when the lamp is at the right height, between two plumb lines lying in a plane perpendicular to the photometer bar and passing through its zero, or by direct measurement from the face of the metal plane.

The work done by Mr. Harcourt towards the production of a thoroughly reliable standard of light, and the success which has attended his previous efforts, are sufficient guarantee that the new form of lamp will not only prove a thoroughly reliable instrument, but will be found not less accurate than the previous forms invented by him; while the practical experience of the makers of the lamp and their well-known accuracy in the production of scientific instruments will ensure the lamp being so made as to bear successfully the test of everyday work.

COMPANIES' MEETINGS.

THE INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY.

The 24th ordinary general meeting of the shareholders in this Company was held on Tuesday afternoon at the City Terminus Hotel, under the presidency of Mr. S. William Silver.

The report stated that the net profit for the year amounted to £13,174. 10s. Adding £37,955 13s. 5d. brought forward, and deducting £20,800 interim dividend paid in July, there remained a disposable balance of £30,330. 3s. 5d. The directors, therefore, recommended the distribution of a dividend of 10s. per share, making, with the interim dividend, a total payment for the year of 10 per cent., and leaving £9,530. 3s 5d. to be carried forward.

The **Chairman** said it was unnecessary for him to remark that the report presented a state of things very different to the results of many years past. The directors had endeavoured to explain the cause in the report, namely, that the little submarine cable business open to tender had been keenly competed for. The contracts secured by the Company had given inadequate employment to its cable works and steamers during the year; and the expenses of the submarine telegraph engineering staff and plant, though reduced as far as it prudently could be, had borne heavily on the gross earnings. This check to their prosperity, he hoped, would only be temporary. The few orders for submarine cables had told doubly against the results of the year. On the one hand they had not made the same profit in that department as in former years, and certain fixed heavy charges which could not be avoided, if they were to be efficient and ready to execute contracts, had been thrown upon the other branches of their business. It was not too much to expect that electric lighting would shortly come into general use. This branch had occupied a vast amount of anxious attention on the part of the board in order that they might be prepared to meet the demands, however extensive. Their works were, in all respects, in the highest state of efficiency. Under these circumstances the directors had no hesitation in applying some of the profit balance of previous years to the purpose to which it was originally intended—namely, towards equalising dividends.

Mr. Neil Bannatyne seconded the adoption of the report, which, on being put to the meeting, was carried *nem. con.*

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The 24th ordinary general meeting of this Company was held on Tuesday at the offices, Old Broad-street, Sir Daniel Gooch presiding.

The **Chairman**, in moving the adoption of the report and the payment of a dividend of £1 16s. a share (making the distribution for the year £2 8s. a share, or 20 per cent.), stated that the Company had laid a considerable length of deep sea cable, and had done some heavy repairs for the Brazilian, the Anglo-American, and the German Union Telegraph Companies. They had made about 8,000 miles of core wire. They were doing much better than hitherto in their gutta percha business, and he hoped that that would continue. It would not be advisable for him to go into details relative to their business.

Mr. Philip Rawson seconded the motion, which was carried unanimously.

The retiring directors and auditors were afterwards re-elected.

SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).

The fifth ordinary general meeting of the Swan United Electric Light Company (Limited) was held on Tuesday at the City Terminus Hotel, under the presidency of Mr. J. S. Forbes.

The formal notice of the meeting was read by the acting secretary, Mr. Gover, Major Flood Page being absent on a mission to Berlin in the interests of the Company.

The **Chairman,** in moving the adoption of the report, congratulated the shareholders on the improvement in the position of the Company, the balance of profit for the year ended September 30 last having been £7,554, compared with £4,768 in the previous year. The total sales for the year had amounted to £27,128, as against £22,000 in the previous year, and the stock on hand at the close of the year was £8,221, against £8,945 a year previously. They held shares to the amount of £208,500 in the Edison and Swan Company, whose business last year resulted in a profit of £16,000, which would have been available for dividend but for the fact that the loss made in previous years had had to be extinguished. That loss, however, was now wiped off. They proposed in their own case to use in a similar manner the profit they had made last year. The loss made by the Company in the previous years had been reduced to £5,000, which it was proposed now to clear off, and they would then start afresh with a balance of £1,720 in favour of the current year. In the case of both companies they were progressing in the sale of the articles they manufactured, and he supposed it was now pretty apparent that, notwithstanding the obstruction thrown in the way of the electric light by legislation and litigation, it was making rapid progress. As the result of the litigation they had succeeded in establishing their claim to the patents in Great Britain. They had had many fights. They had won the contest of Woodhouse and Rawson, which was very important, and on appeal they had won all the points on the Edison and Cheeseborough patent, so that they were—of course, subject to that decision being overruled, which was not likely—the owners of every incandescent lamp in Great Britain. The position abroad was not quite so settled or advantageous. There they were in litigation, and that had dragged on for a long time, and arrived, as far as it had gone, at no conclusion; it was all *in nubibus* still. But they were still going on manufacturing and selling lamps. The question was what it was prudent and reasonable to do in that matter. They had tried to do abroad what they had done at home to so much advantage, and he would undertake to say that if the Swan and Edison companies had gone on litigating there would have been no such thing as £16,000 profit last year nor any year in which the litigation had continued. By putting their forces together, however, they had made a strong company. He was in hopes that he might be able to announce some sort of treaty or agreement with the foreign companies, embodying and bringing into life that desirable result; but he could not. In Paris they had had communication with the manager of the Edison Company, who were contesting the right of selling in France and in Belgium and in Austria and in Russia; and they had come to something like a basis of arrangement, under which it was proposed they should become partners in the lamp business, just as in the case of the Edison and Swan—that

was to say, put all assets into one pot and divide the profits in proportions. Unfortunately, Mr. Edison's friends seemed to have made some very loose agreements, and the freedom of the French company and their powers to deal were in some measure made difficult by complication in those agreements. One of the principal litigations was going on in Germany. We heard a great deal about the delays of the law in England; well, it might be some consolation to some to know that in Germany it was something more awful. These patent cases had been on for three years, and as far as he could see they were as far from the decision as they were a long time ago. They were very anxious to get rid of this German litigation, as it was very difficult indeed to get Germans, with that same energy and untiring love of work, from doing what they did in other places—push over the frontier to sell their wares. That was a reason for making them partners if they could. Major Page was now on his way back from Berlin to tell them the result of his interviews with the parties who pulled the string. If they did succeed in putting things together he had no hesitation in predicting—though he knew predicting was very unsatisfactory, for if one hit the right mark he did not get much credit for it, and if he happened to go wrong everyone abused him—but in this case he would venture to predict a very capital thing for their property. They had their patent for six years, and if they acted with prudence they would, when the protection of the patent ceased, have established a reputation and a connection which would enable the Company to compete with all comers.

Mr. F. R. Leyland (the deputy chairman) seconded the motion.

Messrs. J. Verity, Reynolds, Hedges, and others commented upon the position of the Company, and, in reply to the questions,

The **Chairman** stated that they had obtained protection for their patents as the result of immense litigation, and in regard to the litigation pending with the Anglo-American Brush Company they could give up nothing of the security which they had gained. At the request of the chairman,

Mr. Crisp (the solicitor to the Company) stated that they were proceeding in the litigation with the Brush Company on precisely the same lines as they had proceeded against Messrs. Woodhouse and Rawson, and exactly the same issues were being raised. A second action brought against the Company by the Brush Company was as to their lamp, but they could not discover what possible ground there was for bringing that action.

The motion was then unanimously adopted, and the retiring directors and auditors were subsequently re-elected.

COMPANIES' REPORTS.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION (LIMITED).

Report of the directors to be presented to the shareholders at the seventh ordinary general meeting of this Company, to be held at the Cannon-street Hotel, London, E.C., on Friday, March 2, 1888, at 12 o'clock:—

During the past year there has been renewed activity in the electrical industry both at home and abroad, and although in the present state of electric lighting the business still calls for sacrifices out of proportion to the rewards it offers, there are indications that it is entering upon a new phase, and the directors have reason to hope that the time is now not distant when the work done by the Corporation will be of a sufficiently profitable character to admit of the regular payment of dividends. The electric light is becoming more and more to be regarded as the light of the near future. Clubs, hotels, passenger steamers, and war ships are not considered complete unless provided with the electric light, and in the case of theatres lighting by electricity is now recognised as one of the necessary precautions against danger from fire. Municipalities also, whether they own gasworks or not, are showing an increasing inclination to encourage the establishment of central stations for the supply of electricity. The board have, therefore, continued to pursue the policy fully explained in the last report, of developing the business of the Corporation, and of anticipating as far as possible the demands which will arise in connection with the carrying out of both public and domestic lighting on a large and commercial scale. With this view patent rights have been secured in connection with the distribution of electric currents of a high electromotive force to be distributed over large areas, and transformed to a low tension for domestic purposes. Considerable progress has been made by the Corporation, in common with others, with this system of distribution, as well as with that by means of accumulators, and the board are now negotiating in several directions for contracts for the establishment of central stations for the supply of electricity. In matters of detail the Corporation have made appreciable advance during the year—in the further improvement of their machines and other apparatus, in the better organisation of the business, and in increasing the aggregate amount of their transactions. It is to be regretted, however, that owing to competition and consequent reduction of prices, profits have not increased in anything like the same ratio as the volume of business. Among the satisfactory features of the year's work may be mentioned the lighting of the Royal Jubilee Exhibition at Manchester, by means of nearly 600 arc lamps, to the entire satisfaction of the authorities, and the success which attended this work has materially contributed to the Corporation receiving the contract for lighting the largest part of the forthcoming exhibition at Glasgow, by means of 500 arc lamps. The Corporation also took an important part in the lighting of the American Exhibition in London. They have also carried out a large number of installations in clubs, theatres, on board ship, &c., some of the more interesting being the Lyceum Theatre, Edinburgh, the installations *on board the* Peninsular and Oriental Company's steamships "Victoria" and "Britannia," the Hall of the Worshipful Company of Drapers, and the Royal Albert Hall. The long pending negotiations with the Commissioners of Sewers, for the lighting of a part of the City of London, have been pushed forward with energy, and although a definite decision has not yet been arrived at, the board trust that the matter will speedily be brought to a satisfactory conclusion. It was stated in the last report that the Corporation had acquired the business of the International Electric Company in Austria-Hungary. During the year this business has been energetically developed, and there are good indications that it will constitute an important source of revenue to the Corporation. The firm of Kremenezky, Mayer, and Co., in Vienna (under which title the Corporation are there trading), have carried out a variety of satisfactory contracts during the year, whilst at Temesvar, in Hungary, where upwards of thirty miles of streets are lighted by electricity, the Corporation have since taking over the installation materially increased the efficiency of the plant, and reduced the expenses of wo king so that the balance is now on the right side, and the Corporation, having undertaken to supply the light to private consumers, are taking steps to extend the capacity of the works In the previous report the directors referred to the litigation which was then pending in regard to the infringement by a few manufacturing firms of the patent, held by the Corporation, for compound winding of dynamos. The directors are glad to be able to report that the suit has been amicably settled out of Court, Messrs. Crompton and Co., and their colleagues, having accepted licenses from the Corporation upon the usual terms, and paid a sum of money in satisfaction of past royalties and legal costs incurred. In connection with this case it became necessary to take the evidence of Mr. C. F. Brush, in America, by commission, and Mr. Percy Sellon, the Corporation's electrician, who was entrusted with the mission, obtained evidence which, as was anticipated, confirmed the position of the Corp ration in regard to this matter. Licenses to manufacture compound wound machines, under the Corporation's patent, have now been accepted by all the leading dynamo manufacturers in this country, including Messrs. Siemens Bros., Messrs. Crompton and Co., the Edison Swan Company, Messrs. Mather and Platt, Messrs. Elwell-Parker, Messrs. Greenwood and Batley, the India Rubber Gutta Percha Company, Messrs. Goolden and Company, Messrs. Patterson and Cooper, and many others. One firm of manufacturers in Scotland have as yet declined to accept the very moderate terms demanded by the board, and for the protection of the licensees of the Corporation the board have lately instituted proceedings with a view to prevent the infringement of their rights. The cross actions with the Edison-Swan United Electric Company, in which the Corporation were involved at the time of the last report, are still pending, but are expected to be heard shortly. This litigation, while exceedingly to be regretted, from its serious character to your interests, is, however, of far graver importance to the Edison-Swan Company, involving as it does the validity of the most important of their incandescent lamp patents, which as would appear from their balance sheet, stand at about £300,000, and upon which they rest their claims for an absolute monopoly of lamp making. The board take this opportunity of placing on record their regret that their efforts to bring about an amicable settlement, consistent with your interests, have failed, and that everything points at present to the necessity of the case being submitted to the final decisions of the courts of law. The board have, however, given their careful consideration to the matter, and have spared no trouble or expense to ensure success in the Law Courts, and the great strength of the evidence they have been able to collect, combined with the high legal and scientific advice by which they are guided, enable them to state their full confidence in the result. The Bill introduced last session by Lord Thurlow to amend the Electric Lighting Act of 1882, based as it was in a large measure upon the evidence taken by the Select Committee of the House of Lords in 1886, was very favourably received, and passed by that House, the Prime Minister expressing the opinion that the enterprise should be allowed full scope, that all obstacles which had hitherto impeded it should be removed, and that terms should be offered which experience had shown capitalists would accept. The prospects of carrying the bill through Parliament were therefore very good, had it had proved possible to proceed with it in the House of Commons last Session. The Bill has been, however, reintroduced by your chairman, and there appears a reasonable prospect that it will become law this Session. The capital account shows an increase of £34,939. This is due to carrying into effect the agreement with the International Company, already referred to, which involved the issue of 1,476 fully-paid shares, and to the issue of 1,354 new shares, under the resolution passed at the last meeting, giving the directors power to issue new capital for the purpose of developing the business. Owing, however, to the fact that this new issue was not largely responded to at the time, the directors thought it expedient to make a call of £1 per share upon those shares upon which the sum of £3 only had been paid. The increase in the patents, development, and goodwill account of £3,580, is due mainly to the reacquisition from the Eastern Electric Light and Power Company in liquidation, of the Brush and Lane-Fox patents for the whole of the Indian Empire, exclusive of those for the Presidency of Bombay and the Nizam's dominions, which had already been disposed of by the liquidators The increment includes also the unrealised balance of the assets realisa tion accounts which apeared in previous balance sheets in connection with the absorption of the Great Western and Brush Midland Electric Light Companies, and which has been so dealt with in accordance with the principle laid down at the time of taking over these companies, and the payments during the year for up-keep of patents. It will be seen from the balance sheet that there is a marked increase in the amount owing to the Corporation, which evidences the larger volume of business. It will be perceived that despite the larger operations conducted during the year, the general charges show a reduction of about 5 per cent. Several of the economies effected by the directors now appear in the accounts for the first time; amongst these may be mentioned a reduction in comparison with the previous year of nearly

£500, in carriage and freight, owing to an alteration in the classification of electric apparatus, which was conceded by the railway companies in the early part of the year, as the result of representations made by the Corporation. The directors have also been successful in effecting several other and larger economies, which, however, are not yet reflected in the accounts. Among these may be more particularly mentioned the surrender of the lease of the premises at Portpool-lane, and of the recent sub-letting the Borough-road works. The item of gross profit, which shows a substantial increase upon last year's figure, includes the amount of £3,132, being the estimated value of the fully-paid shares in the International Company held by the Corporation, and which were relinquished as part consideration for the Austro-Hungarian business. The gross profit strictly due to the current business shows an increase of about 12½ per cent. The directors propose that of the balance of profit £2,500 be added to provision account, and that £2,562 12s. 1d. be carried forward to next account. The directors, following the precedent of numerous other industrial undertakings, have, after mature consideration, decided to adopt the principle of remunerating the chief officers in proportion to the net profits distributed by the Corporation. The arrangement is that an amount equal to 10 per cent. of the dividend declared shall be set aside as a fund to be divided, in proportion to salary, amongst the officers from time to time nominated by the board under specified conditions. The board are satisfied that the adoption of this plan will, in view of the appreciation expressed by the staff, have results highly beneficial to the proprietary; and the Board, therefore, cordially recommend it for adoption by the shareholders. Owing to pressure of other engagements, Lord Sudely found it necessary, last spring, to vacate his seat at the board; and, in July last, Major-General Webber exchanged the position of managing director for that of consulting technical adviser, an office which, in view of the immediate prospect of street and private lighting contracts, is one of daily increasing importance to the Corporation. The directors who retire this year, by rotation, are Mr. J. S. Sellon and Mr. J. B. Braithwaite, jun., who, being eligible, offer themselves for re-election. Messrs. Cooper Brothers and Co., the auditors, also retire, and offer themselves for re-election.

PROVISIONAL PATENTS, 1888.

FEBRUARY 17.

2430. **An improved method and apparatus for effecting the regulation of electrical currents.** William Harding Scott and Edward Alexander Paris, 1, Queen Victoria-street, E.C.

FEBRUARY 18.

2438. **Improvements in the manufacture of illuminating conductors for incandescent electric lamps.** Rudolf Langhans, 45, Southampton Buildings, London.

2449. **Improvements in systems of and mechanism for electric railways.** Orren Allen, 52, Chancery-lane, London, Middlesex.

2450. **Improvements in electrical measuring instruments.** Walter Hibbert, 8, St. Dunstan's-road, West Kensington, London, Middlesex.

2454. **Improvements in the insulation and method of fixing electrical conductors.** Walker Moseley, 52, Kimberley-road, Peckham.

FEBRUARY 20.

2515. **Improvements relating to dynamo-electric generators and motors.** James Feaveryear, Gray's Inn Chambers, 20, High Holborn, London, W.C. (Complete Specification).

2516. **A new or improved apparatus or inductometer for measuring the intensity of a magnetic field.** Georges Miot, 46, Lincoln's Inn-fields, London, W.C.

2525. **Improvements in arc electric lamps.** Charles Richardson, 46, Leopold-street, Weaste, near Manchester.

FEBRUARY 21.

2586. **Improvements in and relating to incandescent electric lamps.** Rankin Kennedy, 96, Buchanan-street, Glasgow.

FEBRUARY 22.

2666. **Improvements in dynamo machines and electromotors.** John Vaughan Sherrin, 77, Chancery-lane, London, W.C.

2667. **Improvements in primary batteries.** John Vaughan Sherrin, 77, Chancery-lane, London, W.C.

FEBRUARY 23.

2689. **Improvements in the construction and method of arrangement of electrical incandescent glow lamps.** Arthur French St. George and Christen Rees Bonne, 41, Eastcheap, E.C.

2690. **Improvements in apparatus for indicating the depth of water in reservoirs or tank by electricity.** Luke Berry, Bank Buildings, George-street, Sheffield.

2694. **Improvements in batteries.** William Frederick Charles Ward, 1, Langton Cottages, Melbourne-square, Brixton-road, S.W.

2695. **Improvements in electric lighting.** Samuel Miller, 1, Langton Cottages, Melbourne-square, Brixton-road, S.W.

2698. **Improvements in the construction of sanitary and magnetic mattresses.** Edward Parker Dove, Sunbridge Chambers, Bradford, Yorkshire.

2703. **Improved means or apparatus for sounding at sea and elsewhere by electricity.** Frederick Hargrave, 38, Chancery-lane, London, W.C. (Complete specification.)

2726. **Improved means of laying electric light conductors.** Alexander Thomas Kinninmont and William Henry Gastrell, 53, Chancery-lane, London.

COMPLETE SPECIFICATIONS ACCEPTED.

FEBRUARY 23, 1887.

2819. **An improved method of combining and arranging apparatus operating electric lamps for signalling and other purposes.** Hermann Nerlinger, Strasbourg, Germany.

2825. **Improvements in or applicable to dynamo-electric machines.** John Grice Statter, Norfolk House, Norfolk-street, London, W.C.

MARCH 26, 1887.

4549. **Improvements in electric incandescent lamps.** Albany Featherstonhaugh, Junior, United Service Club, Charles-street, London.

APRIL 7, 1887.

5199. **Improvements relating to the distribution of electrical energy for purposes of locomotion.** William Lowrie and Charles James Hall, 433, Strand, London, W.C.

APRIL 12, 1887.

5303. **Improvements in dynamo electric machines.** Henry Willock Ravenshaw, Walter Thomas Goolden, and Alexander Pelham Trotter, 23, Andalus-Road, Clapham, London, S.W.

APRIL 15, 1887.

5505. **Improvements in dynamo electric machines.** Henry Willock Ravenshaw, Walter Thomas Goolden, and Alexander Pelham Trotter, 23, Andalus-road, Clapham, London, S.W.

APRIL 18, 1887.

5637. **Electrical controlling apparatus.** Alexander Siemens and Edward Frederick Hermann Heinrich Lauckert, 28, Southampton Buildings, Chancery-lane, London, W.C.

APRIL 21, 1887.

5833. **A combined gas motor engine and dynamo electric machine.** Francis William Crossley, 28, Southampton Buildings, Chancery-lane, London, W.C.

5835. **Improvements in contact makers, especially suitable for connecting wires.** Denys Leighton Selby-Bigge, 24, Southampton Buildings, London, W.C.

APRIL 27, 1887.

6177. **Apparatus for adapting electric lamps to the helmets of divers.** Albert Marcilhacy, 28, Southampton Buildings, London, W.C.

JULY 12, 1887.

9731. **Improvements in or appertaining to ammeters.** William Phillips Thompson, 6, Lord street, Liverpool. (George Westinghouse, Junior, United States).

OCTOBER 19, 1887.

14,204. **Improvements in medico-electrical apparatus.** John Randolph Hard and Thomas Wilson, 191, Fleet-street, E.C.

JANUARY 24, 1888.

1078. **Improvements in switches for making and breaking electrical circuits.** Sigmund Bergmann and John Thomas Dempster, 23, Southampton Buildings, Middlesex.

SPECIFICATIONS PUBLISHED.

1887.

747. **Applying electricity to propel vehicles.** F. Wynne. 8d.

949. **Electrical switch.** G. Percival. 8d.

2419. **Dynamo-electric machines.** F. Bosshardt. (Hillaire-Desbois.) 8d.

4546. **Dynamo electrical machines in combination with motor engines.** C. D. Abel. (Siemens and Halske). 8d.

4553. **Electric telegraph apparatus.** W. Dickenson. 11d.

4914. **Switches for electric circuits.** R. D. Smillie. 8d.

7530. **Electrical transformers.** J. G. Statter. 8d.

15,858. **Dynamo-electric machines, &c.** W. Main. 1s. 1d.

16,032. **Electro-motors, &c.** W. Main. 11d.

1883.

217. **Secondary batteries.** J. S. Sellon. 11d.

1644. **Secondary batteries, &c.** J. S. Sellon. 8d.

1881.

225. **Electric lamps, &c.** St. G. Lane Fox. 8d.

1882.

319. **Secondary batteries.** J. S. Sellon. 4d.

1881.

129. **Galvanic polarization batteries.** J. H. Johnson. (Faure). 8d.

NOTICE.

The Notices hitherto sent by the Office to Applicants for Patents, reminding them of the date for filing a Complete Specification, will not in future be issued.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	98 to 100
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
15 Feb.	10/0	Anglo-American	100	41
15 Feb.	20/0	— Pref.	100	67x
12 Feb., 85...	5/0	— Def.	100	15
29 Dec.........	3/0	Brazilian Submarine.........	10	12
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
15 Feb.	8/0	Cuba	10	12¾x
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	3½
18 Oct.	5/0	— 10% Pref.	10	9½
14 Oct.	2/0	Direct United States	20	9⅛
12 Jan.	2/6	Eastern	10	11⅜
12 Jan.	3/0	— 6% Pref.	10	14¾
1 Feb.	5%	— 5%, 1899	100	109
28 Oct.	4%	— 4% Deb. Stock	100	106
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12 5-16
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	105
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	104½
12 Jan.	5/9	German Union	10	9¼
27 Jan.	1/6	Globe Telegraph Trust......	10	5⅝
27 Jan.	3/0	— 6% Pref.	10	13½
3 Jan.	5/0	Great Northern..............	10	14¼

Dividend.		Name.	Paid.	Price. Wednesday
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	107
28 July	10/0	India Rubber, G. P. & Tel.	10	18
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
16 March ...	5%	Maxim Western..............	1	¼
15 May	5%	Oriental Telephone	11	½
14 Oct.	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2¼
15 Feb.	15½%	Submarine	100	145x
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	38¼x
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	13¾
......	...	West African.................	10	5
1 Sept.	5%	— 5% Debs.	100	93
29 Dec.........	6/0	West Coast of America ...	10	5¾
31 Dec.	8%	— 8% Debs.	100	116
14 Oct.	3/9	Western and Brazilian......	15	9½
14 Oct.	3/9	— Preferred	5½	6⅜
......	...	— Deferred..................	2½	3¼
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	105
......	...	West India and Panama ...	10	¾
30 Nov.	...	— 6% 1st Pref.	10	10
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Sept.	6%	— 6% Sterling	100	104

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Jan. ...	£39,878	+ £547
Brazilian Submarine	W. Feb. 17 ...	£4,420	...	Great Northern	M. of Jan. ...	21,400	+ 1,000
Cuba Submarine	M. of Jan. ...	3,300	+ £82	Submarine	None	Published.	
Direct Spanish.....................	M. of Jan. ...	1,943	+ 39	West Coast of America	M. of Jan. ...	4,800	...
— United States	None	Published.	...	Western and Brazilian	W. Feb. 17 ...	3,612	...
Eastern...............................	M of Jan. ...	56,164	+ 2,729	West India and Panama	F. Feb. 15......	3,310	+ 298

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ending February 24th amounted to £4,643.

Western and Brazilian Company.—The traffic receipts of the Western and Brazilian Telegraph Company (Limited) for the week ending February 24, after deducting the fifth of the gross receipts payable to the London Platino Brazilian Telegraph Company, were £2,750.

Bournemouth Electric Light and Power Company (Limited).—Registered by Peacock and Goddard, 3, South-square, Gray's Inn, under Table A. Capital £4,000, divided into 800 shares of £5 each. Object: to supply approved renters in the town of Bournemouth and its neighbourhood with electric light and power, and to carry on the business of an electric light and power company in all its branches. The first subscribers are:—

	Shares.
F. J. Bright, bookseller and stationer, The Arcade, Bournemouth..	1
J. Denkin, architect, Bournemouth	1
J. J. Allen, house furnisher, The Quadrant, Bournemouth............	1
H. Hammond, draper, Bournemouth	1
P. W. G. Nunn, physician and surgeon, Bournemouth	1
C. P. Fippard, cook and confectioner, Bournemouth	1
J. S. Helyer, architect and estate agent, Bournemouth	1

This is the Company referred to in our note on p. 170 of last week's issue.

Gulcher (New) Electric Light and Power Company.—This Company is formed for the purcha-e of the goodwill, patents, plants, materials, stock-in-trade, contracts, and other property of the Gülcher Electric Light and Power Company (Limited). Owing mainly to losses sustained in the years 1882 and 1883, the Gülcher Company, so the prospectus states, was unable to continue trading advantageously without some kind of reconstruction. Accordingly, with a view to reconstruction, the Company went into voluntary liquidation, and *shortly afterwards a committee* of investigation was appointed to report upon its condition and prospects, and to advise as to the course which should be pursued. The capital is £70,000 in 70,000 shares of £1 each, of which 50,000 are 10 per cent. preference shares, and 20,000 are deferred shares. The business is acquired in consideration of a payment of £16,000, and 20,000 deferred shares to the liquidator of the old Company. The present issue is of 25,000 preference shares.

House-to-House Electric Light Supply Company (Limited).—Registered by W. Capel Slaughter, 18, Austinfriars, E.C., with a nominal capital of £350,000 in £5 shares, of which 100 shall be founders' shares, and the remaining 69,900 shall be ordinary shares. Object: to reconstruct a company recently registered. The first subscribers are:—

	Shares.
Robert Hammond, 117, Bishopsgate-street, E.C.	1
F. W. Bentley, 117, Bishopsgate-street, E.C.	1
J. Whitehead, Heycot, Crouch End, N.........................	1
C. G. Hadock, 2, Uxbridge-villas, Shooter's-hill	1
H. St. John Wentworth, 11. Harrington-road, S.W.	1
W. Capel Slaughter, 18, Austinfria's, E.C.	1

The number of directors shall not be less than three nor more than nine, and the first are George Richardson, Professor R. Bentley, G. B. Godfrey, A. B. Trotter, and R. Hammond. Qualification, 100 shares or £500 stock. Remuneration £1,500 per annum, and in addition one-tenth of the annual profits above £7 per cent. on the ordinary shares (after providing for a reserve fund), but the whole remuneration is not to exceed £3,000 in any year. This is the company whose prospectus we discussed in our leader of last week. We understand the Company has gone to allotment, and one paper says has "sent out letters of regret." We shall investigate the amount subscribed and if, as we suspect, the directors have gone to allotment upon a comparatively small amount of the £175,000 first asked f r, it is a fact the investing public ought to know.

NOTES.

Germany.—Ten years ago, on the 20th of February, 1878, the first introduction of electric light into industrial establishments took place. It was the firm of Schimmel and Co., of Leipzig, which first of all practically and profitably adopted this new source of light in their workshops.

Silico-carbon Filaments.—According to *Cosmos*, the filaments for the Seel lamps are produced by impregnating silk or woollen thread with a mixture of silicate of soda and gum arabic. The threads are then passed between the two heated cylinders, and, lastly, are carbonised at a high temperature.

The Electric Light in Greece.—M. H. Rée, the new director of the works in connection with the drainage of Lake Capais, in Greece, has just put forward a proposition to utilize the available water power, equivalent to that of 12,000 horses, for the electric lighting of Athens, the Pyreus and Chalcis.

Government and the Telephone.—In the House of Commons on Tuesday, in answer to Mr. Provand, Mr. Raikes said : In reply to the hon. member, I have to state that no scheme for the purchase of the telephone companies' interests is being considered by the Government, nor is any such scheme in contemplation.

Underground Conductors.—The Electrotechnical Society of Berlin has nominated a Committee to consider the question of underground electrical conductors. This Committee is composed of the foremost electricians of Germany, including Messrs. Werner Siemens, Helmholtz, Elsasser, Von Miller, Froelich, Golz, &c.

Book Received.—"On a Surf-bound Coast, or Cable Laying in the African Tropics," by Arthur P. Crouch, B.A., Oxon. Sampson Low, Marston and Co. This book forms portion of a diary kept during a cable expedition down the West Coast of Africa, starting from the English Settlement of Bathurst and terminating at the Portuguese town of St. Paul de Loanda.

Electro-Chemistry.—Amongst the recent communications to the *Académie des Sciences*, of Paris, is a note by M. F. Fournier, entitled, "A method by which may be established the mathematical relations between the physical properties and the chemical properties of simple or compound bodies. Dynamo-electrical law of chemical reactions." The communication may be of special interest to some of our theoretical readers.

Barcelona.—A destructive explosion of gas occurred on the 27th ult. at the Town Hall, where the Queen Regent is to occupy apartments during the Exhibition. Partitions were thrown down, the heavy *persienne* blinds blown into the square, and the marble balcony was damaged. A gasman was seriously injured, and eight other persons were more or less hurt by the falling stones. The building is being repaired, and the electric light installed throughout.

Sweden.—The building of the new gigantic steam sawmill at Korsnas is now rapidly progressing. One of the engines is quite ready, and the other will shortly arrive from Messrs. Bolinder's works at Stockholm, which supply all the machinery. Besides these two engines, there will be two more, one for the electric light and the other for the mechanical works. The laying on of the electric light is now progressing by workmen from Stockholm, and will be completed in a few weeks.

Furness Railway.—On Friday last, about 6 o'clock, flames were observed to break out in the telegraph stores of the Furness Railway Company at Barrow, a building about 150ft. long and built of wood. It was stocked with very valuable stores, and owing to the inflammable nature of much of the material the fire soon had a firm hold of the building. There was a great scarcity of water, and in about an hour and a half the entire building was destroyed, the damage amounting to many thousands of pounds.

Street Railways.—An affidavit has been filed referring to the Bentley-Knight electric system, in connection with a petition from the North and East River Railway Company of New York, to the Legislature of that State, by Mr. J. J. Houghton, the effect being that, in his opinion, and in view of the successful operations of the said Bentley-Knight system in other places, and, after a careful consideration of the plans, certified by the engineers of the road and submitted to him, Mr. Houghton is certain that successful operation of such a system cannot be called in question.

Bismuth.—In the course of experiments on the heat conductivity of bismuth when placed in a magnetic field, it was observed by A. Righi that the isothermic lines were rotated in a direction opposite to that of the magnetising current when a rectangular strip of the metal was placed with its planes normal to the line of force. The phenomenon is analogous to that observed by Hall, namely, the rotation of the equipotential lines when a magnet acts on a current flowing along a thin strip of metal, and may explain the thermomagnetic currents recently discovered by Ettingshausen.

Melbourne.—The forthcoming International Exhibition to be held at Melbourne will be lighted by means of 800 Brush arc lamps of 2,000 nom. c.-p. and about 3,000 incandescence lamps of 17 c.-p., operated by 37 No. 7L Brush dynamos and 7 E2 Victoria machines. The Anglo-American Brush Electric Light Corporation have just contracted with the Australasian Brush Electric Light Power and Storage Company for the supply of the whole of the dynamo machinery and arc lamps required for this extensive installation, and have undertaken to ship all the apparatus by the end of the first week in May.

Journal of the Society.—The new number of the *Journal* of the Society, just issued, contains the President's Inaugural Address, the conclusion of the discussion upon Mr. Cockburn's paper on "Safety Fuses," as well as an abstract of the papers which have appeared in Foreign Publications, and a list of the important articles which have also appeared in such publications. The discussion which arose out of the paper on "Fuses" is of itself of importance, and should be studied by all electric light engineers, because it contains the experience of those who have been engaged in the industry from its commencement.

Electrolysis.—When an electric current passes from a solution of certain metallic salts with the atmosphere of gas or vapour immediately above such solution, an electrolytic separation of the metal takes place at the surface of the liquid. M. J. Gubkin has recently described (Ann. Phys. Chem.) certain apparatus by means of which this is made evident, and in which a partial vacuum may be produced above the liquid. Silver and platinum are found to separate out in films which float on the surface; whilst zinc, in contact with air, oxidises as it separates; the white

flakes of zinc oxide gradually falling to the bottom of the liquid.

House of Commons.—Mr. Hobhouse on Monday asked the First Commissioner whether he proposed to take any steps this Session for establishing electric communication between the library and the House, so as to inform members occupied in the library of the progress of debate and the names of speakers. In reply, Mr. Plunket said the question of the establishment of electrical communication between the House and the library and other parts of the building has been considered, but there has not been up to the present time sufficient unanimity of feeling among hon. members in favour of the proposal to justify him in going on with it.

The Telephone in Hospitals.—We take the following from a "society paper":—"There is a talk of applying telephones to the infectious wards of the French hospitals, so as to enable the sick people isolated in their contagious sufferings, to have the comfort of hearing their relatives' voices, without any risk of conveying infection by an interview. It certainly is a very humane idea, and would not, one would think, be a very costly one to carry out. We commend it to the benevolence of some English millionaire who wants to do a good deed, or wishes to perpetuate the memory of some beloved relative by a benefit to his suffering fellow creatures.

The Optical Projection Stenotelegraph.—This apparatus, devised by M. Lambotin, has been laid before the committee of consultation for posts and telegraphs recently constituted by M. Coulon, the director-general of this department in France. It allows of the optical production, by means of an electric or oxyhydrogen lamp, of stenographic signs or characters, which may be photographed upon a screen at the distant station in communication, or which may simply be read from station to station by means of a telescope. It is proposed to utilise this system more especially in time of war and during the night, when the services of the carrier pigeon are not available.

Arc Carbons.—According to the *Revue Scientifique*, the most advantageous thickness of carbon for arc lamps, taking the currents specified, is given in the following table:—

Current in amperes.	Diameter of carbon in millimeters.	Current in amperes.	Diameter of carbon in millimeters.
2 to 3	2	15 to 24	13
3 to 5	4	16 to 25	14
4 to 6	5	25 to 30	15
7 to 10	7	30 to 45	17
10 to 11	9	35 to 60	18
11 to 15	10	40 to 80	20
12 to 16	11	50 to 120	25
13 to 20	12	80 to 180	30

For heavy currents, our contemporary recommends bundles of carbon rods of 4mm. diameter or fluted carbon rods.

"L'Electrotherapie."—This is the title of a new periodical devoted to the subject of medical electricity and published in Paris (11, Rue de Magador). It is edited by Dr. Leon Danion, who has secured the scientific collaboration of Messrs. Bernhardt, of Berlin; Onimus, of Paris; De Watteville, of London; Vizioli, of Naples; Weiss, of Vienna; and Virgilio-Mathado, of Lisbon. Amongst the articles contained in its first issue is one by M. H. Rével, in which the necessity for the accurate galvanic measurement of currents applied to various portions of the system is duly insisted upon. It would certainly be most interesting, here in London, to be informed of the value in *milliamperes* of the currents evolved from appliances largely advertised by "eminent" medical electricians.

The Electric Light in Paris.—The electric lighting firms in Paris have something equivalent to our Electric Lighting Act of 1882 to contend with, in the shape of the *Cahier de Charges*, or Conditions of Contract, elaborated by the Committee of the Municipal Council of Paris. Great dissatisfaction has been expressed in many quarters in relation to the obligations and restraints imposed upon concessionaires. The most recent expression of this feeling is to be found in a circular, which has been addressed to their clients by Messrs. Ch. Mildé, Son and Co., who were to have carried into effect the electric illumination of the Monceau quarter, by means of a central station distributing the light to the Parc Monceau, Malesherbes, les Ternes, and the Champs Elysées. The circular simply states that, in view of the onerous conditions imposed by the Municipal Council, the firm has relinquished the idea of establishing the central station in question.

Selenium.—Amongst the selenium cells constructed by S. Kalischer, three were found to differ from the rest in their behaviour on exposure to light; the resistance rapidly increasing after undergoing a momentary decrease, and the cell returning to its normal condition only after remaining for some time in the dark. Copper and copper-brass electrodes were used in these three cells. The conclusion has been drawn from the above phenomena that the cells in question contain a hitherto unknown modification of selenium, the conductivity of which decreases, instead of increases, under the action of light. It may be, however, that the effects are dependent upon the nature of the electrodes, as the remaining cells have electrodes of zinc, copper-zinc, or copper-platinum. Experiments have been made by M. Bellati and S. Lussana upon the influence of light upon the heat-conductivity of selenium. They found the value 1 : 1·1 as the ratio of the heat conductivities without and with exposure to light.

Electric Lighting in Spain.—The *Gas World* is hard upon the Concessionaire who proposes to obtain motor power for electrical purposes from the falls of Manzanares. It says:—"Electric lighting in Madrid is very much hampered by the local regulations which practically prevent steam engines being set up within the city. A concession has been given to M. Gabriel Faura for bringing in electricity from the falls of Manzanares, some 14 miles from Madrid. This river is very variable; in winter it flows in a wide and turbulent stream, and the bridge across it at Madrid is a very long structure. In summer, on the other hand, it is nearly dry, and the disproportion between the large bridge and the meagre stream is so great and apparent that it has given rise to a local proverb. When a person appears to make a greater display than his resources would presumably permit, he is said to be like the Manzanares: 'he has sold the river to pay for the bridge.' It remains to be seen how far such a stream is suitable for electric lighting."

The Elements not Patentable.—In arguing the Bell telephone case before the Commissioner of Patents the other day, says the *Scientific American*, Robert G. Ingersoll, one of the counsel, closed his argument with the following pertinent remarks, which it will be well for all inventors to remember. The conclusions are sound and as applicable in other cases as the one on which the learned counsel made the application:—"I do not believe any man can patent the idea of sending speech by electricity. He can patent de-

vices by which that can be done, but he cannot get a patent on the lightning. A man can patent a water-wheel, but he cannot patent the water, or say to the water you cannot turn any other wheel but mine. A man can patent a windmill, but not the wind; and any man who can make a better mill may use the same wind, because we do not get our entire stock of wind from the Patent Office or from the attorneys on the other side. Wind is the free gift of all politicians; and, looking at the attorneys of the Bell people, without wind where would your case be?"

The Caloriphone.—This name has been given to a very wonderful but not altogether novel—nor, as yet, perfected—apparatus, devised by a young French soldier and *licencié ès sciences*, M. Léon de Pontois. The object is to obtain telephonic communications without the use of a conducting wire; the distance between the communicating stations being comparatively very great. The inventor, in fact, speaks of an apparatus, weighing 10·5 kilos, and costing from 80f. to 100f., which will communicate through a distance of ten French leagues. The system by which this result—which for the present we are fain to accept with a grain of salt—may be obtained is summarised as follows:—The conversion into luminous undulations of the vibrations impressed by the voice to a telephonic plate; the reception of these undulations by an optical apparatus of great power; their conversion into calorific undulations; and their reaction upon a substance, such as selenium, which, by transmitting them to a telephonic receiver, transforms them into articulate words. According to the *Revue Internationale*, experiments with this apparatus are immediately to be made between Mont Valérien and other forts in the vicinity of Paris.

Rather Inconvenient.—A curious thing occurred last Thursday evening, when we had quite severe lightning, says the Orlando, Fla., *Record*. One of our surveyors was out in the woods surveying, and on the approach of the storm took shelter under a large tree, leaving his compass on the jack staff, some two or three hundred yards away. During the storm a tree very near the compass was struck by lightning, and, strange to relate, the effect upon the compass was to reverse it so as to make the north point of the needle change position and point south. The gentleman not knowing that fact, when he went back to the compass took a sight and started, as he supposed, for home. After walking eight or ten miles, going north, as the compass indicated, he, away in the night, came to the house of an old settler, who, upon inquiry, told him where he was and how far from Orlando, and the proper direction, which, of course, was exactly opposite to that indicated by the compass. After becoming satisfied something was wrong with the compass, and that the settler was right, he retraced his steps, and arrived at home tired, wet, and cross. This is the second instance we have known of the needle of a compass being affected by lightning so as to become reversed.

Improvement in the Edison Lamp.—We translate the following from our excellent little contemporary, the *Bulletin International de l'Electricité*. The paragraph refers to the Edison lamps employed for public lighting:—"In the case of public installations, when all the lamps are simultaneously rendered incandescent or extinguished, the arrangement in series offers numerous advantages from the point of view of simplicity of construction and working. A somewhat serious difficulty, however, arises from the fact that any lamp accidentally breaking down must be automatically thrown out of circuit, in order to prevent the extinction of all the lamps. After numerous experiments, the Edison Company of New York has arrived at a very simple device, which appears to give very successful results. A third platinum wire is passed into the glass bulb, between two bunches of the filament. In the stem of the lamp this platinum wire is connected to a very fine iron wire, by which a spring is maintained in a condition of tension. When the filament of a lamp becomes broken, a voltaic arc becomes formed between the positive extremity of the carbon on the one hand, and the negative extremity and platinum wire on the other hand. The current thus traversing the latter suffices to fuse the iron wire, allows the spring to act, and by this means establishes a contact which cuts the lamp out of circuit. By means of this contrivance, the series arrangement may be adopted without any inconvenience."

The Schanschieff Battery.—On the occasion of the opening of the new line of the London and South-Western Railway to Bournemouth, a new feature in railway travelling was introduced in the form of electric lighting by the use of the ordinary roof lamps. A number of these ordinary lamps belonging to the company had been altered into electric lamps by the use of the Schanschieff primary battery, several of the saloon carriages being so lighted. Several forms were adopted, some lamps being fed from the outside by simply moving a plug; but by far the most interesting ones were lighted or extinguished from the inside by simply pulling a chain. These latter were much appreciated, as being very convenient for sudden lighting for tunnels, or extinguishing easily in case sleep might be required, to say nothing of the saving in cost. The light was very clear and white, and remained remarkably constant and steady throughout the whole trip. Great interest was manifested in the light, and we believe several railway directors expressed their intention of recommending its adoption. We learn that similar lamps are being made for other companies. During the trip Mr. Schanschieff also exhibited the guards' hand lamps, and other of the Schanschieff electric appliances, which are attracting great attention in the railway world. These are practical experiments, and by the results obtained, after a moderate interval devoted to such trials, we shall be better able to judge the value of such a method of illuminating railway carriages.

New Edison Lamps.—The march of improvement in the Edison system, says the *Electrical Review* of New York, has resulted in the perfecting of a new type of lamps of much greater economy than those which have been made by them so many years. Broadly stated, the new High Economy lamp of the Edison Company carries with it a saving of one-third the power required for the former style, and whereas the company formerly guaranteed 8 to 16 candle-power lamps to the mechanical horse-power, they now guarantee 12 for an expenditure of the same power, or 15 to the electrical horse-power. The old plants of the company are being rapidly fitted with the new lamp, which, of course, marks in the mind of the user of the plant the fact that electric lighting is making substantial progress. The new 16 candle-power Edison lamps range from 90 to 125 volts, and require only $3\frac{1}{10}$ watts per candle-power. The 100 candle lamp is also one of the new type of lamps, and ranges from 90 to 125 volts, requiring an energy of $3\frac{1}{10}$ watts per candle power. Always specially constructed for use with storage batteries of comparatively low E.M.F. (60 volts) and re-

quires only $2\frac{1}{2}$ watts per candle power. The Edison Company is now also making a series of lamps of similar economy for battery purposes, but running from 20 to 40 volts and from 10 to 32 candle-power. Another lamp is used in connection with Edison central stations. It is of high resistance, and requires 150 volts to bring it to incandescence. When therefore it is run at 110 volts it gives but a dim light, and this is what is desired, the lamp being intended for a night lamp, in bed rooms and other places where only a small amount of light is desired.

Motors and Mining. — The *Western Electrician* (Chicago), in calling attention to two installations for mining purposes, says :—"In one instance the contract calls for the delivery of 2,000 horse-power, three miles from the primary source—a water-power—on an island, and the circuit will cross an arm of the sea 4,000ft. wide. In the other instance a circuit of 18 miles will be erected and power distributed at fourteen different points along the circuit. Our contemporary has repeatedly called attention to the mining regions of the west as a most promising field for the electric motor. In many places the price of fuel is prohibitive, especially where the only method of transportation is on a burro's or mule's back up steep mountains. If the method were reversed and, Mahomet-mountain like, the ore were transported to power for crushing, again the cost would be prohibitive ; but if power could be applied directly at the mine without too great cost, then the cost for transportation would lie in taking the net products of the ore crusher to market. In the mining districts it frequently happens that water power in abundance is found, but at too great a distance from the place where the application of power is desired to be utilisable. For instance, one miner had this problem ; a mine that promised to yield ore of high grade but located on a mountain side six miles away from power ; no method of transportation, save on mules' backs, and with that method of transportation a cost of production that forbade development of the mine. The miner is now investigating the electric motor. The two installations described are important in that they will bring the electric motor prominently before the mining interests of the country, and show what achievements can be attained by the electrician, and they are important and interesting to electricians on account of the problems involved and the methods of solution adopted." We have no doubt that such firms as Messrs. Immisch and Co., who make a speciality of motors, have not overlooked the immense field for the use of their motors the mining world represents, and will not allow America—if English energy and enterprise go for aught—to monopolise this work.

Electric Lighting in France.—The work in connection with the central station at Tours is progressing satisfactorily. A few of the shops in the *rue Nationale*, along which the mains have been laid, are still lighted with gas ; but the cafés, the circus, the theatre, and all the largest establishments in the quarter employ the electric light. The number of lamps actually working is about 2,000, and will shortly be augmented to 3,500. The current is supplied by three alternating-current dynamos. In regard to the financial results of the enterprise, which were at first unsatisfactory, in consequence of the low charge of $3\frac{1}{2}$fr. per 16-candle lamp per month made to subscribers—the lighting being from dusk till 12.30 a.m.—these have been made remunerative by the adoption of a tariff of 5 centimes per lamp hour ; the minimum period of lighting being four hours per lamp per day. We regret to say that the central station at Vierzon, inaugurated a few months ago, has not been a financial success—experience in this as in other directions having in some cases to be paid for. The experience gained by the *Société d'éclairage électrique de Vierzon* will no doubt, however, be valuable to other companies undertaking similar work. At Lyon the question as to the general adoption of electric lighting remains undecided ; the Municipal Council desiring, apparently, to stimulate to the utmost a competition resulting in a lowering of the price of the gas supplied to this city.—The administration of the *Chem de fer du Nord* is actively carrying out the electric lighting of the stations on its lines. That at Pontoise is shortly to be supplied with 90 incandescence and two arc lamps ; the motive power available will be 35 horse-power. The station at Busigny will have a 70 horse-power motor, working 130 incandescence and 12 arc lamps ; whilst that at St. Ouen l'Aumône will be the occasion for a transport of energy through a distance of 1,200 metres with the object of charging the accumulators in connection with the incandescence lamps for lighting the offices. Lastly, the quantity of light at the station of Plaine St. Denis is to be more than doubled ; the number of arc lamps becoming 17, and the incandescence lamps 100. The Krisic arc lamps are to be employed in these installations.

Cost of Electric Lighting.—Our contemporary, *Industries*, commenting in its last issue upon the Maxim-Weston offer to light the City, says :—"This company offered to erect a central station generating plant, and eight hundred small arcs throughout the City, for the modest sum of £15,000, and to work the plant for an annual charge of £3,875. The lamps were to be 450 n.c.p., and to be kept alight from sunset to sunrise, that is, roughly speaking, for 4,300 hours per annum. The lamps are presumably the Watt lamps, about which a great deal has been written in the daily press, and nothing at all has transpired in the scientific journals. To judge by the reticence observed both in the matter of the dynamo and the lamp, the inventor seems to prefer the verdict of the non-scientific newspaper reporter to that of a skilled electrician when he submits his invention for inspection. We have, therefore, no means of knowing anything about the merits or otherwise of the Watt lamp ; but assuming this small lamp to be as efficient as an ordinary 10 ampere lamp—an assumption which is by far too favourable—each lamp would require 225 volt-amperes ; and allowing a loss of 25 volt-amperes for the leads and regulating devices, we find that each kilo-watt generated at the station would maintain four of these lamps alight. For the 800 lamps, the total capacity of the generating station would have to be about 200 kilo-watts, and the yearly output 860,000 Board of Trade units, which, calculated at the low figure of $6\frac{1}{2}$d., represents a charge for current alone of £2,325, to say nothing of the cost of carbons, which will probably amount to one-fifth of a penny per hour per lamp, representing an additional outlay of £2,800 per annum. This does not include the cost for trimming lamps nor outdoor supervision, which must necessarily be high where a large number of small lamps is employed. From our figures it is obvious that the Maxim-Weston Company must have made some mistake or other in estimating the annual working expenses, which they will find out to their cost, and perhaps to that of the City also, if they obtain the contract on these lines. It is obviously

the advantage of any community to get contractors k for them at a loss, for in such cases the public is to be badly served. We may therefore also dismiss axim-Weston proposal as impracticable on account of nic reasons, and the question remains whether arc g in any shape or form would be an improvement he present system of gas lighting."

City Lighting.—A good deal of correspondence s subject has appeared in various papers, but two in the *City Press* of the 3rd inst. put the matter as it s to users. One correspondent, signing himself ion Street" protests that the arrangement between rush Company and the Corporation was foolish, over too long a period, the advantages were rated, the system of lighting contrary to every ig of science, the system should not be arc but incan- t for streets, and the evidence as to price was incon- . The concluding sentences of the letter are as :—"When a company appears on the scene prepared to contract, under penalties, to supply lights of this kind, at the same price, light for as gas, then we can think of it. When it will it cheaper than gas, without too many chains round nsumers, then we may adopt it. Till then I venture ertion that while glow-lamp lighting is the best pos- orm of light for interiors, no proof has yet been that there is any advantage whatever in electricity as for the purpose of street illumination." The igned "A. L. F." treats the subject from a business of view, and from his letter we cull the following es :—"Take Wood-street as an example. In this ghfare there are eighteen gas lamps of 16 to 20 power, at a cost of £65, where the business cannot be less than 25 millions sterling yearly. xtra cost to light this thoroughfare properly would ut £100 per annum. This is really, where such a volume of business is transacted, not worth con- ion, and the difficulty about lighting one portion of ty brilliantly at the cost of the other parts not so , could be easily overcome by charging the district evious agreement) an extra rate. Failing the of this suggestion, a guarantee fund could be any morning in Wood-street from the propietors leading warehouses. Buyers from all parts of the visit this locality to make purchases, and any one can tand the depressing effect a miserably-lighted street in r's afternoon has on the spirits of a buyer, having a ll of commissions in his pocket. Its dreary, miser- ghted thoroughfare would, under the circumstances, yers new to this country the impression that they ne to the wrong market, and that they ought to defer their purchases until they visit Paris or Berlin. It arvel there are so few accidents or robberies after such a narrow crowded thoroughfare so badly lighted. no doubt due in a great measure to the excellent gilant City Police organisation. If the City Council make a few inquiries within their own boundaries blishments where gas has in a great measure been d by the electric light, they would find sufficient e to warrant their deciding it its favour. Apart is, if they were to refer to doctors who practise as ans for the wholesale houses, they would find ng proofs of many young men's health having been through having to work day after day underground ted atmospheres mainly caused by gas. From a rcial point of view, a brilliantly-lighted city is likely to give a fresh impetus to trade, and have a marked bene- ficial influence on those occupied in it."

A Private Installation. — Mr. George Vaughan Fowler, a member of the firm of Fowler, Lancaster and Company, electrical engineers, of Birmingham, has carried into effect a complete installation of the electric light at his residence, the "Old House," near Warwick. The fol- lowing details of this installation have been given by the local press. The engine-shed contains a Spiel's petroleum engine used to drive the dynamo. The engine at Mr. Fowler's house is nominally two horse-power, but will work up to about three and a quarter horse-power. It requires only a few feet of room, and is attended to by a boy of 15. This engine drives, by an endless belt, made of small links of leather combining great strength with flexibility, one of the Fowler Lancaster shunt-wound three unit dynamos. These dynamos embody the latest improvements, are free from "sparking at the brushes," are very durable, and are besides of extremely neat appearance. The current, generated in the dynamo, is led, by the ordinary cables, to a neighbouring outhouse, to a set of "E.P.S. accumulators," and this forms one of the most interesting features of the installation. The accumulators in Mr. Fowler's installation hold sufficient current to supply his lamps for three winter-days' consump- tion. There is thus no need to run the engine at night time when the light is required, or on Sundays. In the day time the accumulators can be charged, and by always keeping a day's supply in hand a temporary breakdown in the machinery would not involve the house in total darkness. By a simple arrangement, the connection between the dynamo and the accumulators would then be automatically cut off. From the accumulators the current is led into the house through a switchboard placed on the landing. Upon the board there are several switches. One is a main switch, which cuts off the current from the house and stabling altogether, and the several minor switches cut off or supply the current to various quarters of the house and premises. Each lamp, in its turn, has a small switch to itself in the apartment where it burns, so that any of the lights can be on or off at will. The house fittings are of a most handsome character. There is nothing in connection with the light that is unsightly, nothing in fact that is not artistic, and that does not add to rather than detract from the appearance of the room in which it is placed. There are altogether in the house 54 lamps, of 50 volts, varying from 8 to 50 candle-power. The lamps at the gateway are of 50 candle-power each. They are enclosed in globes of glass slightly frosted on the inside, which are placed at the top of thin iron supports resting on the gateposts. Their light is most efficient, and it is possible to read small print over 30 yards away. The stables are also fitted with the electric light. The main point which determines whether such a luxurious system can become general in large country resi- dences is that of the cost. It is said the cost of this installation is above double the cost of oil. That the system gives advantages which no other kind of lighting can approach cannot be denied. It follows, therefore, as a matter of course, that as soon as the system becomes known many gentlemen will adopt it at their homes. No damage is done to paint or ceilings in putting in an instal- lation, and the leads are more easily laid than gas-piping. There is no danger of fire. Should an electrical short- circuit take place by accident, ill consequences would be averted by the fuses with which each switch is provided.

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

(Continued from page 153.)

One instrument for measuring differences of potential deserves special notice, inasmuch as its action depends on neither of the properties of the current already mentioned. I refer to the Cardew voltmeter, in which the expansion of a platinum-silver wire, caused by heating due to the passage of the current, indicates the difference of potential at the ends of the wire. Since heat is employed to give the indications, the instrument can be kept on continuously without introducing temperature errors, which in the case of other instruments become fatal to accuracy. It can also be employed to measure alternating differences of potential, since there is no lag due to self-induction.

For the measurement of electric power several instruments, termed *wattmeters*, have been devised, but they have not come into general use. Generally, a wattmeter consists of a pair of coils; one a fixed coil of coarse wire through which the whole current in the circuit flows, the other a movable coil of fine wire, to the terminals of which is applied the difference of potential between the two points between which it is desired to measure the power. The mutual attraction between the coils measures the watts, and the movable coil may either be moved against a controlling force, and caused to take up a position depending upon the power being measured, or the tendency to movement may be balanced by the torque of a spring, or by weights in a scale pan. The former is an indicating and the latter a zero instrument. The wattmeter, though it tells us the product of current and difference of potential, does not tell us anything regarding the magnitude of the two factors. If the current were 20 amperes and the difference of potential 100 volts, the wattmeter would show 2,000 watts, but it would give the same indication were the amperes 200 and the volts 10. The instrument is therefore unsuitable for general use, for by multiplying together the indications of an ammeter and voltmeter we can always obtain the power being used in the circuit, and the exact way in which the current and difference of potential are related.

To obtain the resistance between two points of a circuit in which a current is flowing, we have simply to divide the difference of potentials in volts between those two points by the current flowing in amperes, *i.e.*, divide the reading of the voltmeter by the reading of the ammeter. But in cases where there is no current flowing we have recourse to the Wheatstone's bridge method, which need not be enlarged upon now as it has been already fully described in this journal by Mr. Thomas Gray.* In his article will also be found a description of the precautions which have to be adopted in employing the method, and the degree of accuracy which can be obtained by it.

15. Mechanical Measurement.—For the measurement of mechanical quantities there has been devised a number of instruments to which the generic title of dynamometer has been given. A dynamometer in the usual acceptation of the term is therefore any instrument which measures mechanical work or power. Beginning at the prime mover, we have for the measurement of the power given out, the steam engine indicator, which draws to scale the diagram of work done in the cylinder for each stroke of the engine.† On the exterior of a drum, which has a reciprocating rotary movement given to it by means of a cord attached to the crosshead, is fastened a piece of paper on which is drawn, by a pencil moving parallel to the axis of rotation, the indicator diagram. The pencil holder is connected by levers to a piston moving in a small cylinder which is in communication with the cylinder of the engine. The pressure of the steam on the underside of the piston is counteracted by a spring, and the height to which the pencil rises indicates the steam pressure at any moment. The stroke of the engine in feet being represented by the movement of the drum about its axis, and the pressure of steam in pounds per square inch by the compression of the spring, a diagram is drawn by the instrument, the area of which gives the work done in foot pounds per stroke on each square inch of piston area. Of course it will be understood that the pressure in the cylinder is varying from moment to moment throughout the stroke, and that to obtain the mean pressure we must take diagrams from both ends of the cylinder. The indicator pipes are generally attached so that, by turning a cock, the diagrams from both ends can be drawn on the same paper and without disturbing the indicator. Having obtained from the diagram the mean pressure, we multiply this by the area of the piston in square inches, by the stroke in feet, and by the number of strokes per minute, when the product divided by 33,000 gives the indicated horse-power. From what has been already said the reader will perceive that the indicated horse-power is an average rate of doing work. The pressure in the cylinder and the velocity of the piston are continually varying throughout the stroke, so that the rate of performing work is sometimes considerably above the indicated horse-power, at other times considerably below it. What the above product really gives is the average pressure into the average velocity, and therefore the average rate.

But the engineer is not satisfied with knowing only the power of the engine driving his dynamos. It is doubtless very satisfactory for him to know that for a certain indicated horse-power he gets a certain amount of light; that from his dynamos he gets in electrical energy 70 per cent. or so of the energy given by the engine; but there is here a total loss of 30 per cent., and he wants, as far as possible, to find out where the losses occur. Really, if it were not too much trouble, he might set up apparatus which would enable him by careful measurement to write out a balance-sheet with all the credits truly set forth, and balancing the amount of power debited at the engine. But usually he has to be contented with a balance-sheet somewhat imperfect, though nevertheless useful. A description of the apparatus employed to make the necessary measurements, having this end in view, we shall reserve for another article.

(To be continued.)

* *Electrical Engineer*, February 10, 1888, page 128.

† As the various methods of measurement can only be described here in a general way, the reader is referred to a useful little book on "Indicator Diagrams," by Prof. Kennedy's chief assistant, in the press, and about to be published by Messrs. Charles and Co.

SCHLESINGER ELECTRIC LOCOMOTIVE MOTOR.

The work of Mr. W. M. Shlesinger, the electrician of the Union Electric Company, in the field of electric traction has attracted considerable attention, and we are glad to be able to give further descriptions and illustrations of his work.

The motor represented by Figs. 1 and 2 is capable of giving 35 h.-p., and is designed especially for locomotives having to haul heavy loads. It is 27½in. broad, 43½in. long, and 22in. high, and weighs, with countershaft and gear, 1,500lb. The armature is of the Siemens drum type, 9¼in. in diameter, and has a core 10½in. long. The wires are wound within troughs fastened to the core of the armature, and are thus prevented from being displaced either to one side or to the other by the pull exerted by the magnets on them. This pull with a motor varies from one side to the other as the direction the motor runs in as altered, and tends not only to loosen the wires, but also, by causing them to move, gradually to destroy the insulation.

The armature makes about 1,000 revolutions, the countershaft about 400. The bearings of the latter are part of the same frame in which the two armature bearings are cast. This keeps the two shafts parallel under all conditions, and insures an easy running of the gears, even with the most trying alteration in the load. After six months' running, the teeth of the pinion showed a wear of $\frac{1}{64}$ of an inch, *i.e.*, about $\frac{1}{128}$ of an inch on each side of the tooth.

The 32 part commutator is placed outside the bearings, and is constructed in such a manner that it can be taken off and replaced by a new one within an hour and a half, it being unnecessary to disturb any of the other parts of the machine, or to make any electrical connection otherwise than to solder the wires into grooves in the commutator

bars. As all these wires are so arranged that they can be placed in no other groove than the one to which they belong, it requires no electrical knowledge or training to accomplish this. The great advantage of this method can be seen when comparing the time and work required for the exchange of an old commutator for a new one on this moter, with that required for a motor having the commutator inside the bearings. With the latter it is not only necessary to take the motor more or less apart, but also to remove it from the truck or car to which it is attached; furthermore, in most cases (nearly always when the Siemens type of armature is employed) the front cap has to be removed, and it requires a thoroughly trained workman or electrician to replace the wires. All this requires from 8 to 24 hours' time and about 3 men. Having the commutator outside the bearing, it has the further advantage of allowing at all times an easy inspection of it and the brushes, and facilitates the proper setting or adjusting of the latter.

One of these motors has been running for the last six months in the Lykens Valley Coal Company's mine at Lykens, Pa., hauling daily about 500 tons gross weight over a road 6,300ft. long. This load is gradually being increased, and it is expected to haul about 1,000 to 1,300 tons gross weight daily. Some of the work this motor has accomplished was to haul a train weighing about 150 tons, consisting of 31 cars, and 380ft. long, round two curves, the one having a radius of 20ft., and the other 30ft., and the distance between them being 180ft. This same train had afterwards to be started while standing partly on a level and partly (100ft.) on an up-grade of 15in. in 100ft. The average number of cars hauled by this motor in one trip varies between 10 and 20, these cars being loaded partly with coal and partly with rock or slate. A second motor of the same type will in a short time be in operation in another part of the mine, where it will have to haul daily 300 loaded cars, representing a gross weight of about 1,500 tons, and 300 empty cars weighing about 450 tons, so that the total load of this motor will be nearly 2,000 tons.

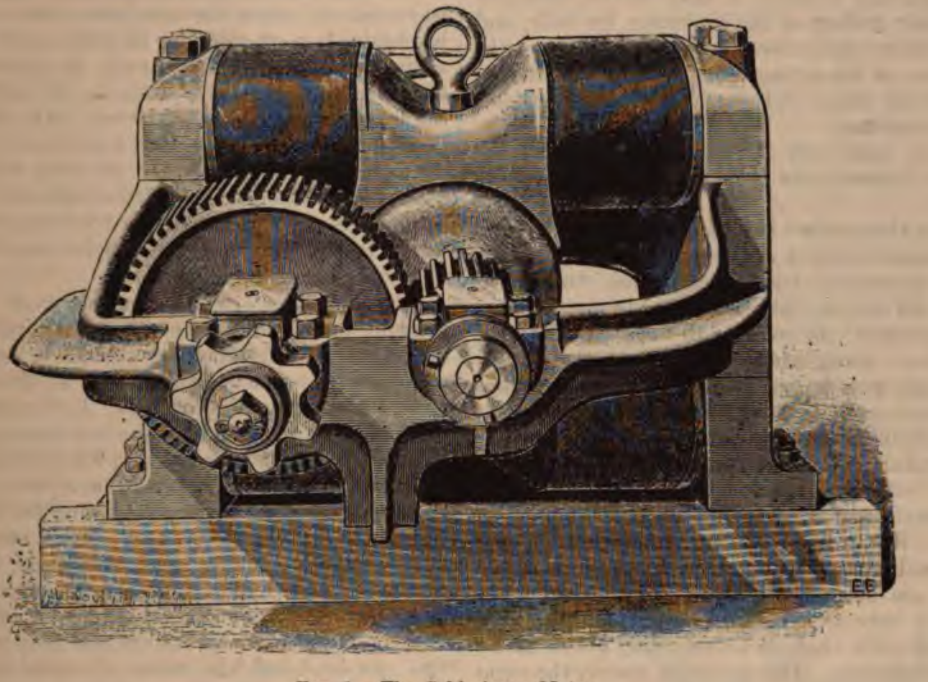

FIG. 1.—The Schlesinger Motor.

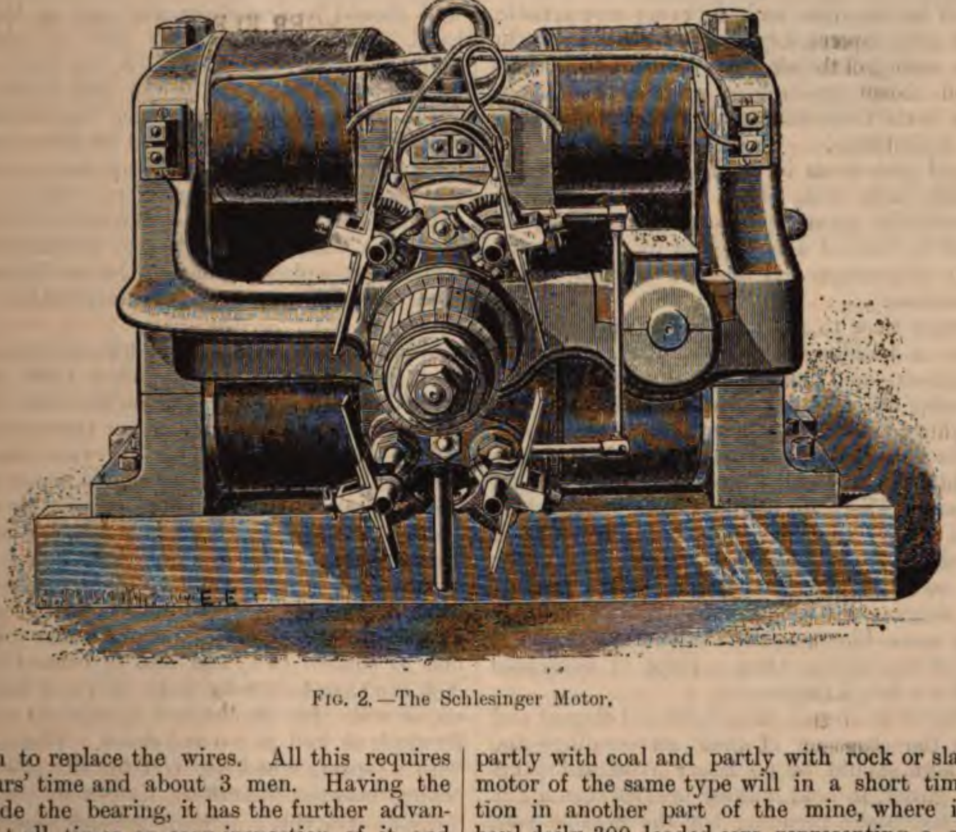

FIG. 2.—The Schlesinger Motor.

ARTISTIC ELECTRIC LIGHTING.*

BY H. SWAN, A.S.T.E.

There are two quite distinct and different ways of considering an installation of electric light. One, that is familiar to us, concerning volts and amperes, wires, switches and fuses, dynamos and engines, is that of the electrical engineer; the other is that of the consumer, his wife, and the interior decorator, and concerns itself primarily with the artistic nature of the fittings, the brilliancy, softness, and disposition of the lamp, and its general suitability and convenience for actual use.

I should like to point out strongly, to those who are electrical engineers, three things to consider with respect to electric lighting.

The first is, that the public—the men who want electric light in their homes—do not care one jot, as a rule, how the electricity is produced; battery, dynamo, storage, or central station, is all one, except as it affects the cost. They do not *care* for dynamos: do not care to *know* about them, do not want to *have* them, and are only too glad to do without them—only put up with them when they desire the light and cannot get it without some generator. What they want primarily is *pure light*, which, when they have it, shall be as beautiful and convenient and dependable as possible.

The second thing I would insist upon is the influence of the ladies—the wives. Some men there are who will arrange, order, and see carried out their own ideas imperiously; but I am sure I only state a fact when I say that generally it is only after long and serious deliberation with the wife that such changes as replacing gas or oil by electricity are undertaken. This being so, clearly the right end to begin at in order to forward the spread of electric lighting will be the careful consideration and greater attention to actual beauty of form and arrangement of the fittings as appealing to the ladies, and to the spread of a greater knowledge of its varieties, conveniences, and beauties for household use.

Thirdly. That although it might appear that handsome effects can only be obtained by paying heavily for them, yet in reality it is not so. It stands, of course, to reason that large and handsome electroliers cost more than plain ones, but I wish to insist upon the fact that for a given cost a place may be fitted to look in every way artistic, well-lighted, and even luxuriously fitted, with exactly the same expense as, done in another way, would have given a plain, mean, and cheap appearance; and simply by the expenditure of a little taste, judgment, and knowledge, as well as of wires and fittings.

Each house, and each room in the house, should be considered separately, hall, club, shop, or dwelling—as an architect considers it in planning it—and not only so, but each room should be treated according to its own requirements both as to disposition and amount of light, and to harmony of decoration.

Nothing is easier than to sling a number of plain cord pendants all over a building—pleasant and easy work for the electrical engineer—and nothing has a more unfinished, mean, and irritating effect, however good the light, to anyone with the slightest artistic feeling for decoration. Think also that the light itself is decorative, the shape of the globe is lovely, the light soft and sweet—itself "a thing of beauty and a joy for ever." There are houses I could name where the incandescent lamps are themselves quite one of the prettiest features of the room. Yet others again have been fitted with no sense of fitness—thick lumping holders, shades of all degrees of crude, inharmonious colours, switches looking more like a small model of a dynamo or some such piece of engineering than a piece of household furniture fitted for a lady's fingers.

The fittings should be chosen, then, light and elegant and in keeping with the character of their surroundings and their duties. There should be no heavy wrought bracket like a cantilever girder, to hold nothing heavier than a 2in. globe of blown glass and a vacuum; but the flexible cord itself should be made use of as far as possible, either alone or decorated with fancy knobs or ornaments (which can be easily and cheaply made of twisted wire or spun brass balls). One of the best effects is with brackets of various designs in twisted brass or light wrought iron work—the flexible cord passing openly in and out, through vulcanite "nipples" where going through the metal, and suspending the lamp at the end.

With the incandescent lamp, unlike gas, nothing has to be considered (after the cost) except the effect required to be obtained, no restrictions of placing for fear of burning or soiling or heating the things in juxtaposition, tables, walls, ceilings, tapestry, pictures—all alike are safe—only the best effect is to be considered. This we are not used to from constant use of gas, and sometimes very beautiful and unconventional effects can be obtained by remembering it. Let us now consider the different effects required in a good dwelling house, and how best to obtain them. I will give one or two hints of how the lighting has been fitted in some of the houses of the West End.

Drawing Room.—The principal room is generally the drawing room—here is most light required and most variety advisable. The electroliers should be open as far as possible, not too much shaded, that is, should aim at dispersion, not concentration of light. In a small room, a 5-lamp electrolier is often used, with one or two additional standards or brackets at either end. If a long room, it is advisable to have two of them. In a low room, a series of brackets round the walls is preferable; in a high one, the electrolier takes off the sense of emptiness. A device often used in good houses when gas has not been used, but candles were preferred, is to adapt the candle sconces, if handsome, with flexibles from behind the wall, and holders fitted with a brass plate in which are two small holes. Into this can be fitted the wires of a semi-circular silk shade, made on a wire frame fitted with white silk, or coloured, or ornamented, according to taste. The shades are fitted to stop the light striking the eyes, and reflect it on to the wall, thus giving a soft general light over all. It is a good thing in all rooms of any pretension to run round behind the skirting a "lead and return" with sockets for moveable attachments at intervals round the room, and to have one or two table standards with shades that can then be moved about as desired and connected by long flexible cords.

Switches.—The switches in the movable fittings should be in the fittings themselves. The switches to sconces on the wall should be near them, and just at the height of the hand. It is a nuisance to have to search around in unlikely corners for the switch, but for an electrolier it is often best to place the switch just inside the door, as it opens the hand finds it at once; occasionally it is placed just outside, and can be turned on before entering.

Candlesticks to be adapted are better not drilled, but a plate should be screwed or driven in the top, and the holder with attached flexible cord fastened to that. The holder should be neat, not straggling or mechanical looking, and is better electro-plated to match the candlestick. Silk shades, movable, can be adapted to candlesticks as well as to sconces.

Dining Room.—Unlike the drawing room, the light here want concentration. The dining table is the centre of attraction, and a bright light on the table, shaded from the eyes, and comparative dimness at the corners of the room, is the desideratum. One or two lamps, in sconces, brackets, or standards, of 10 candle-power, can be placed at the sideboards; but the chief lighting for the dining room should be enclosed in a large hanging dome or silk-covered shade spreading over the table, and capable of being moved up and down by a counter-weight arrangement. For an ordinary table, five 16 candle-power lights is a good number; and it is well to arrange them with two switches, one to control two, and one to control the other three. You can then have two, three, or (with both on) five lamps on, at will. In some cases it is required to travel back and forwards as well as up and down. This can be arranged with a spring wheel (to coil up the slack), fixed in the ceiling between the rafters, if desired.

Hall.—For this you want a good general light. A 32 candle-power lamp is advisable "to welcome the coming, speed the parting guest." A good effect is got by having a lantern made of upright rows of round clear glass rods arranged cylindrically with the lamp in the centre. Lamps

* Paper read at the City and Guilds of London Institute—Old Students' Meeting.

in the ceiling with cut glass are often used, and also brackets.

Picture Galleries.—These must be considered in two different ways. Do you want a good general light all over, or do you wish a bright picture line and a dim centre? The latter is best for public galleries or show rooms of a large size, and can be obtained by hanging a series of 30 or 50 candle-power lamps at distances of 6ft. to 10ft. all round the gallery not far from the wall and just above the pictures, the lamps to be encircled with hammered shells of metal whitened inside (not brightened or plated, which casts strange lights). These shells should be suspended by cords, and tilted slightly at an incline to throw the light on the picture line.

For a general light, electroliers should be used, or a series of cord pendants, but in either case all the light should be stopped as much as possible from going upwards to the ceiling, and be reflected on the walls. They may be obscured for softness.

For a large picture gallery, 50 or 100 candle-power lamps are useful. A useful addition to a picture gallery is a large reflector on a standard with wheels for throwing light on particular pictures with a 50 candle-power lamp. Single noted pictures are often fitted with their own bracket coming out of the top of the frame and shielded with a shell to throw the light wholly on the picture: it should be whitened or gilded inside.

Ball Rooms.—There are so many different arrangements for ball rooms that it is difficult to say which is best; but for large and high rooms use lamps of higher candle-power. Remember too, that while much light is required, it is wanted soft and harmonious and not too brilliant. Ladies wish to appear at their best, and a too glaring light is not good. An American furnisher has gained society's applause and gratitude by modifying the too brilliant glare of the incandescent filament into delightful softness and harmoniousness by a very simple means. He envelopes each bulb in a small bag fitted with an elastic round its top and made of straw-coloured silk.

Bed Rooms.—The lamps should be available for giving a good light for dressing by, and should be susceptible of being turned on or off from the bed. A table lamp for reading is also required sometimes.

Stairs and Passages should have plain fittings, as a rule, and opal reflectors.

Kitchen and Basement.—Opal reflectors often get broken here, tinned and enamelled iron ones are more advisable. A moveable one on a handle near the fireplace, for introducing into pots, to look at the contents, is very useful to the cook.

Counterweight Pendants.—These are very useful and connenient, and can be used in all sizes and designs, plain or ornamental. Care should be taken that the wheel, or running surface, where the double flexible touches on, is not metal, but vulcanite or ivory—or faced with some insulating material; the hook which keeps the cords together should also be of insulating material.

Cut Glass.—Cut glass has a very fine effect, but is costly, and requires constant cleaning to keep brilliant.

Lamps.—A great deal more can be done than is usually the case by varying the candle-power of the lamps to suit the different situations. It is too often the case that 16 c.-p. lamps are used all round, and floods of light are expended in corners, passages, lavatories, &c., which had much better have had 10's, or even 5's; more light being reserved for where it could be better employed. A 10 candle-power lamp in a double-faced lantern, let into the wall between two lavatories, is often quite enough, and will sometimes efficiently replace two 16's, or four times the power.

Thirty, 50, and 100 candle-power can much more often be used with advantage than is yet usual. Four 50's give an effect equal to, or better, in a large space, than that of twelve 16 candle-power; and, of course, at a cost for renewal of 20s. instead of 60s. One 100 candle-power lamp will light a large shop window splendidly at a very moderate first cost; but it is necessary to have specially made holders for these high candle-power lamps, and a solder contact is better than the contact of two round wires (which, remember, is mathematically no more than a point) to carry 4 or 5 amperes of current.

THE BENTLEY-KNIGHT TRAMWAY SYSTEM.

In our issue of February 24th we described the Bentley-Knight motor and gearing for driving tramcars. We now

Fig. 1.—Contact Plough.

illustrate the details of construction of the conduits, conductors, and contact pieces, or, as they are called, contact ploughs. Fig. 1 shows the contact plough making contact with the conductors in the conduit, the section of which is shown in Fig. 2, and the method of connection in Fig. 3. The conduit, Figs. 2 and 3, in which the conductors are carried is an important part of the system. In construction the iron yokes are set upon the ties, and they are strengthened by webbs let into the ties themselves. The conductors are hung from a continuous insulating lining. The lowest

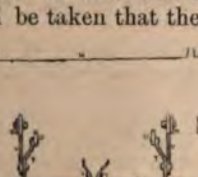

Fig. 2.

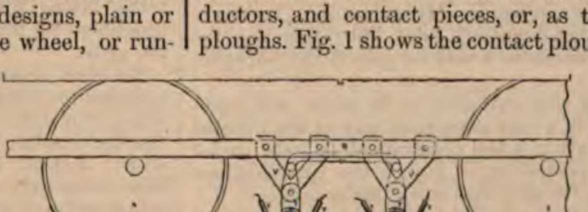

Fig. 3.

A Ties. B Conduit. C Yokes. D Slot-steels. E Braces. E¹ Ears. E² Lag-screws. F Slot steel lining. G Conductors. H Contact shoes. I Plough frames. J Wearing-plates. K Insulation. L Car wheel. M Car bottom. N Supporting frame. O Plough slide. P Plough guide. Q Upper bearing. R Lower bearing. T Plough lever. U Connecting rod. V Plough supports. W Conduit bottom. X Conduit sides. Y Flexible connections.

point of the yokes is less than 15 inches below the surface of the street, while the extreme width of the conduit is 26 inches. The contact ploughs used to make connections between the motors and conductors are provided with swivel joints allowing them to easily take curves, and they are mounted on guides which give them full play across the whole width of the car. These ploughs (Fig. 1) can be inserted or withdrawn from the ⅝in. slot at any point along the line, and nothing can by any accident be left behind to obstruct the progress of succeeding cars. The constant potential system is adopted. The dynamos are compound wound, and Prof. Thomson's new method of winding is adopted, in which the main circuit field coils closely surround the armature and oppose the tendency to a change in the line of commutation under varying loads. The efficiency of the motor is said to be 90 per cent. The current strength usually employed is about seven amperes, but the motor is said to be able to stand 30 amperes for any length of time.

Regulation of speed is effected by resistance in the motor circuit. Both moter and brakes are governed by the ordinary brake handle. A separate lever is used for reversing at the end of the run. Toothed gearing is used throughout for the transmission of power from the motor to the axle. The construction and equipment of 10 miles of tram line per horse-power costs 204,000dols., for electric power 462,000dols., for cable 803,000dols., while the annual running expenses in the three cases are respectively 107,040dols., 51,891dols., and 101,210dols.

If this estimate is even approximately correct, it shows that the annual cost of running tram lines by electricity is far less than by horse-power or cable traction, and although the initial expense for electric construction and equipment is greater than that for horse-power, the annual expense of electric traction is less than half that of horse traction. The engineers state that in all cases the maximum prices have been charged against the electric system and minimum prices against horses and cables. Of course it is extremely difficult to verify such statements, and there is no doubt that the cost must differ very considerably in different places.

INSULATION AND INSTALLATION OF WIRES AND CONSTRUCTION OF PLANT.

BY PROF. ELIHU THOMSON.*

I have been requested to present my views on the above subject, and having recklessly allowed myself, in spite of the many other demands upon my time, to accept the chairmanship of your committee on the same subject, I have felt it my duty to at least say enough to provoke a general discussion and interchange of views between others who may have given more special study to the matters in hand. My endeavour, therefore, will not be to arbitrarily lay down any rules, but rather to point out directions in which information may be gained and improvements made.

The subject is certainly very extensive in its scope, and could not be dealt with except in a very superficial way in the time at our command, and meanwhile I feel constrained to state that I make no claim to the possession of any of the qualifications which would be requisite for thorough work on the subject.

In the installation of an electric light or power plant we first of all find that the conditions vary very widely. Its size, locations, the distance covered, or length of circuits, and the climatic effects met with, need to be considered.

Then, again, the nature of the plant itself, whether arc light, direct incandescent, alternating system with transformers or converters, &c., governs to a large extent the conditions of the installation of the wires and of the plant itself. We may, of course, find in a single station or installation representations of these and other characters of plant, such as medium potential circuits for power transmission alone.

Three or four years ago we should have been required only to take into account simple cases of high potential for arc circuits and low potential direct currents for incandescent multiple arc circuits, but the range now covered may be considered to be from any potential above 50 volts up to several thousands and any current strength from about one ampere up to several thousand ampe:es.

In considering the proper insulation and installing of wires for conveying these potentials and currents, we are required to still further extend our field of view and divide them into aerial or overhead wires or conductors and underground systems, and each of these taken in connection with the conductors for in-door distribution to the lamps, motors, or other energy users. We have thus outlined the field which should be covered in dealing with a subject such as we have before us. Insulation and installation of wires and construction of plant would furnish us a subject material to fill a many-paged volume, and not by any means exhaust it. May such a work soon be forthcoming.

Concerning the relative merits of overhead conductors and underground conductors, it is pretty generally agreed that, except for expense and the difficulties of insulation and connections from the mains, the underground system would be preferable, as avoiding unsightliness and liability of interference either by leakage, inductions, or contacts with other overhead wires. Now, to preserve insulation of the lines conveying high potentials, which potentials cannot be avoided if distance is to be covered without conductors of such size as to have a prohibitive cost, is a vital question. It may well be conceded that when the potentials are very low, say 100 to 200 volts, the difficulties of insulation are very slight as compared with those of the use of two or three thousand volts.

It is a notable fact that so far as concerns the placing of overhead wires, particularly the wires of telegraph, telephone, and other such systems, and in some cases of electric light wires, extreme disregard of systems or orderly direction for such wires is the cause of much of the unsightly appearance presented by them, and much of the liability to get out of order. The tendency also has been to use very light and easily broken wires for telephonic work, such as may at any time come down upon the necessarily stronger electric light wires, strength being synonomous with efficiency in these latter.

It is thought that there is need of some rules or enactments to render impossible the mazes of telegraph, telephone, private wires, fire alarms, live wires, dead wires, and electric light wires (which for our purposes may be considered very live wires), such as may be seen in many of our large cities.

Should the wires of all kinds be laid or hung in orderly bundles having a definite direction, and only changing that direction by definite angles, such as right angles, in accordance with a pre-arranged system, I think that much of the objection now existing to the placing of overhead conductors could be eliminated. Add to this a requirement increasing the durability and tenacity demanded for telephone and telegraph wires and their supports, and the dangers of leaks and grounds would in a large measure be removed.

Many trials have been made, and considerable progress has resulted therefrom, in the direction of securing an insulating covering for electric wires as may adapt them to the use of high potentials without leakage and prevent contacts forming by abrasion with other wires. This appears to be one of the most difficult problems in electric engineering. The problem is not so much to find a first-class insulating substance for wire covering, but to find combined therewith, or to combine therewith, the qualities of indefinite durability where exposed to the weather, and great toughness and power of resisting cutting or abrasion. For overhead work not only is an excellent insulator capable of withstanding very high potentials without leakage or rupture required, but such property must be retained along with the mechanical properties of hardness and toughness for indefinite periods. Besides, the cost must not be too great.

To what extent any quality of insulated wire or insulating material for outdoor use fulfils this requirement is a matter which it is difficult, indeed, to determine fully, particularly as a test for durability must necessarily require a long time to complete. Indeed, it would seem that our best guide must be the experience gained in the use of different wires on a large scale under different climatic conditions and without extremes of heat and cold more or less great.

Aside from the insulation given to the wire by its covering, considered purely as an insulator, most stress must be laid upon the requirement of resistance to mechanical friction or abrasion, as tending to give immunity from grounds by contact with other wires or with tree branches, roofs, cornices, &c. Toughness and elasticity of the insulation are hence seen to be qualities of high importance.

Whether such mechanical tests as will represent the conditions of actual practice in the use of the wire in relation to abrasion and percussion, bending, &c., which may break through the coating of insulation, can be devised and applied to test wires is somewhat doubtful, though without doubt much information may be obtained in the pursuance of such an object.

The retention of the toughness and elasticity for a reasonable period is of course demanded, and it is this retention which in otherwise excellent coverings is often absent, the effect of exposure being to render the materials brittle and porous.

It has often been proposed to make tests for the insulation resistance of the coverings of certain lengths of any wire, taken as examples representing an average for such wires, under potentials somewhat exceeding that existing under actual use or practice, and so to determine the in-

* Read by Mr. E. W. Rice, junr., before the Electric Light Convention.

sulating capabilities of different coverings; but it is my opinion that while such tests are certainly useful and important and, in the case of underground wires and cables, indispensable, yet, for overhead work, since most of the length of the wire is exposed to air only, which is a practically perfect insulator, and since the chance of a leakage from the lines arises most from imperfectly insulating supports and from accidental contacts with other wires or surfaces, additional tests would in any case be required to determine the suitability of an insulator for overhead lines. In this connection it may be stated that during thunderstorms overhead wires are subjected to violent inductional effects, giving rise oftentimes to the momentary charging of the lines with potentials very far in excess of the potentials of any dynamos, and capable of breaking through the wire covering where it may be near or touch a metal object or wet surface. This breaking through may give rise to a weak spot which will be followed by the dynamo current itself, if of high potential, and if at the same time other conditions be favourable to a diversion of current.

When overhead wires or pole lines are required to pass through and between branches of trees, a condition not infrequent in many of our towns and cities, considerable difficulty may be found in preserving the insulation of the line, the covering of which is apt to be rubbed off by the tree branches swaying in the wind. Fastening insulators to the branches for support and attachment of the wires is an uncertain remedy, on account of the swaying of the tree taking place in different directions not transverse to the line of wire, so that the wire is strained or detached from its support along with the insulator by the violence of the actions. Many and ingenious are the devices which the over zealous lineman makes use of to suddenly, or gradually and mysteriously lop off the offending limb, when the case is exceptionally critical, and permission for the amputation of the offending member cannot be obtained from the conservative citizen whose sidewalk supports the obstacle to the lineman's ambitions.

It is also customary to thicken the insulation of the wire at such places as are threatened by abrasion by winding on it a wide band of tough and adhesive tape, such as can now be found in the market. If neatly and thoroughly done, the insulation of the wire may thus often be preserved under decidedly adverse conditions.

It must be admitted that the insulation of a high potential circuit can never be too good, and that therefore any measure which may tend to its improvement and preservation is a double advantage, for not only are the dangers of grounds and leaks lessened, but the power of the current to do useful work is assisted. A considerable leakage from a high potential circuit means, indeed, a loss of power or efficiency of the system. For instance, the loss of one-half an ampere of current at a potential at 1,500 volts, would represent about one horse-power of current energy lost, costing more than a horse-power at the dynamo pulley to supply such a leak. This latter consideration is of especial importance in dealing with the lines feeding transformers with alternating currents at high potentials.

With 1,000 volts in the primary circuit it is readily seen that a badly constructed or leaky line might easily cause the loss of a considerable percentage of current, such as would reduce the economy of the system, more particularly when running under light loads, at which time it is desirable to secure and to keep the best possible efficiency.

When wires or cables are to be laid underground their resistance to abrasion is of importance only when they require to be drawn into conduits or sections of conduits, but when once placed intact they are not necessarily further subject to mechanical injury, as they are generally surrounded by protective casings or tubes.

The total exclusion of moisture and the possession by the wire coverings of a high insulation resistance are requisites of great importance in such work. The difficulties are with low potentials comparatively easy to provide against, but in the case of wires at high electric potentials or pressures, such as arc light or alternating current primary lines, such difficulties are much exaggerated.

The least excess of moisture, such as may occur by flaws in the insulation, may result in the production of a bad ground, or a slight leak, due to some orignal defect, may so improve itself by the passage of current as to become a bad fault or a complete connection to earth. It would seem best in all cases not to place reliance upon the integrity and perfection of but a single insulating coating or covering for the wire, but to give to it, say, three coatings successively applied, and which are, in a measure, independent coverings, all of them impervious to moisture and good insulators. If composed of different materials, the peculiar liabilities to defect of one such coating may possibly be compensated by other qualities in another coating, so that there may be small chance of superposed defects in all coatings alike.

Let but the insulating capacity of each layer or coating be amply good to withstand the potential used, and it is difficult to conceive how trouble could arise from leaks due to defective portions of the covering. First cost is, however, a barrier to the perfection of underground systems, to save which cost less effective and cheaper structures are often given the place which should be occupied by the more perfect and more costly.

It is important that, in cases in which overhead wires or wires above ground are connected with underground lines, efficient means for carrying inductive discharges to earth be provided, such as is secured by the use of proper lightning arresters; for faults may otherwise be produced in the best underground system of conductors due to static inductional discharges existing during thunderstorms, at the moments of lightning discharge. These discharges are in overhead lines oft-times quite vigorous, and capable of puncturing moderate thicknesses of insulation. They are not to be confounded with actual passages of lightning strokes to the lines, which, of course, have an infinitely greater capacity for mischief.

The preservation of the insulation of *inside* wiring is not difficult where the potentials used are low, nor is it difficult with due exercise of care and skill in the running of the wires and the selection of suitable courses for them to take, to install simple series lines, such as those for arc lights, which shall be practically exempt from leakage, unless abraded and brought into contact with conducting objects or moist surfaces involving leak to earth. Unfortunately, owing to lack of skill and judgment and haste in installing, much of the wiring done is not as well done as it should be for the best results.

Distribution of current to groups of incandescent lights upon arc light or other high potential lines should always be undertaken with great care, and it is thought that such work should only be undertaken when exceptionally favourable conditions for avoiding accidental leakages exist, especially should the potential of the line at the dynamo exceed 1,500 volts, or an amount which would sustain thirty arc lamps in series. One of the important elements of safety in such installations is simplicity and ease of inspection of the wiring, and no concealed wires should be used in them.

Concerning the wires which are suitable for indoor work and particularly for high potentials, the endeavour has been to combine moisture proof and fire resisting, or rather incombustible, materials in the covering. The difficulty has been to find moisture resisting substances which would not carry fire, and fire resisting or incombustible material which would not carry or absorb moisture. The two properties seem in most cases incompatible. The tendency now is to surround the wire with a first covering of moisture proof material of the nature of rubber, bitumen, resins, &c., and outside of this to place a second layer which will not carry fire.

For house to house and general incandescent lighting, where the distances from the station are not too great, the direct low potential systems possess most of the advantages, the difficulties of leakage from the defective insulation being of course at a minimum, but where the distances are so great as to make the required outlay for copper in the conductors practically prohibit the extension of the system, a transformer or converter system, if of good design and economy, may be made to yield excellent results. In such cases the high potential primary wires need not enter the building, or when they do may be suitably protected, the house or inside lines being of such low potentials as to be run with ordinary precautions as to leakage. However, the integrity of the system would be changed should a connection or leak form between the primary and secondary wires of the transformer, thus connecting the local or house line with the high potential outside mains. Such a connection might easily exist unsuspected, and would be a constant source of menace or possible danger, not discoverable by the mere tests for grounds as applied to the primary line at the station.

The expedient of securely grounding the secondary or local lines was devised by me to overcome this difficulty. It insures immunity from the risks arising out of possible leaks from the primary lines to the house lines, because such leaks are at once detected by the ordinary tests for grounds.

The consideration of the subject of what appliances are the best for the detection and location of leaks or faults in the insulation of conductors when they exist, and whether the ordinary crude methods are adapted to all cases by such detection would prolong the present paper much beyond its intended limits, and it will have secured its object if it opens up an opportunity or gives occasion for a free discussion and the interchange of experience and ideas upon the general subject forming its title.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS—STUDENTS' MEETING.

A meeting of the students took place on Thursday, the 1st inst., Mr W. M. Mordey being chairman.

Mr. W. E. Hayne opened a discussion upon Mr. Cockburn's paper on "Safety fuses, &c.," describing several improvements, one of which is to replace the leaden pellet, an essential part of Mr. Cockburn's fuse, by a small spring. A duplex cut out was also mentioned (devised by himself and his brother), in which a second fuse is thrown into circuit after some definite time has elapsed, useful in cases of accidental or designed short circuits lasting only for a short time.

Messrs. Lamb, Hume, Rance, and **Mordey** continued the discussion. A vote of thanks to the chairman terminated the proceedings.

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

PRICES AND COMPETITION.

In our article of last week on transformers or accumulators, was a sentence which deserves much more consideration than it is likely to get while embedded in the middle of that article. The sentence we refer to reads as follows:—"It is an open secret that profits on the manufacture of dynamos have of late declined almost to the vanishing point." The fact is too true, and may be accounted for in various ways. This result is partly a legacy left by the electric light boom of 1881-3. Companies were then floated, which, in their eagerness to get some sort of a business, ran down prices so that it became impossible for respectable firms to follow and live. Then, when the pinch came, workmanship was sacrificed to cheapness; purchasers subsequently finding out that their so-called bargains were of a costly kind. The amount paid for attempted repairs was greater than the first cost of the dynamo, and this after a short wear, so that in a good many instances the machine descended into the scrap heap, and its original place knew it no more. The bankruptcy court and the auctioneer—admirable institutions as they are in their way—have much to answer for in the lowering of prices. Another incident in the downward march has been caused by quotations made to get on the Government list. It may be that in some cases the work so obtained was profitable; but we are inclined to think the profits in many cases were of the most intangible character, and we are quite sure the result on the whole has not been satisfactory.

The number of firms entering into the trade and dealing with electrical apparatus is largely increasing; and it is with a view to their interests, as well as in the interests of the older firms, that we have ventured to discuss this subject. The industry is rapidly extending. With energy and caution, new firms may spring up and be successful. Too great a rush however into the business must be deplored, as must every attempt of new firms to obtain business by *unduly* lowering the catalogue prices. Undoubtedly, if the profits obtained in any industry are abnormally large, it is in the interests of the general body politic that more capital and more competition be embarked in this particular enterprise. But it cannot be said of the electric lighting industry that the profits are too large, rather the contrary; so far as balance-sheets tend to show anything they show a fair amount of work at too low a profit. The mere fact of having obtained an order for a dynamo, or for a number of dynamos, in the teeth of rivals may prove a source of gratification for the moment to the particular firm; but, if the order has been obtained by means of too low a quotation, the ultimate result may possibly be the opposite of gratifying. The prime cost of any dynamo can be calculated to almost or quite one per cent. of accuracy, so that there is not

that room for eventualities there is in the calculations for a railway or a canal. Extending the sphere of discussion from dynamos to a complete installation, it is not very difficult to ascertain when too low a tender has been submitted. For example, the consensus of opinion from practical men is against the published amounts as tendered for the City lighting. It cannot for a moment be supposed that the men who have every inducement to support the progress of electric lighting would utter an adverse criticism if it were possible to restrain it. The same line of argument may be pursued in regard to all electrical apparatus. Just as the prices of the best makers of steam engines are approximately the same, so the prices of the best makers of dynamos must also tend to an average. The slight differences there must be will easily be accounted for, inasmuch as one maker will profess to give a detail or details differently to other makers, and maintain that this peculiarity really makes his machine better and cheaper than that of a competitor whose catalogue price for a similar machine is £5 or £10 lower. Output for weight is not the best method of judging the value of a dynamo. Some members of the profession have no other idea than the machine which gives the greatest output for the lest weight is the best. They are wrong. Prices may at first be diminished by the use of too small a quantity of metal; but depend upon it the maintenance will involve a heavier outlay, and the total cost will be more greatly increased than when due attention is paid to the "factor of safety." Another question which as yet has received very little attention even by the most practical firms, is the cost of selling or, as it may be put, the cost of obtaining orders. As competition increases this will bear a considerable percentage to the selling price of the article. We could give a number of specific examples, but it will perhaps be best to cite cases altogether outside our particular industry. One case before us shows the cost of obtaining the order to be between 30 and 40 per cent. of the nett price received for the executed work; the payment for which in most cases extended over a period of 18 months. Another case to the point is where the traveller's salary and expenses came to about £1,000 a year, with returns to about £11,000 to £12,000 during that period. The above amounts are exclusive of advertising expenses. The first case applies to a company in which these expenses are nil—the latter to a company almost or quite the largest advertisers in the world. It will be seen that, without a complete knowledge of the per centage to be added on in the second case, comparison is difficult. However, it may be said that, with every addition made, the percentage cost of the latter was less than *half* that of the former. It is this cost of selling that is seldom taken into account by new firms; and in their innocence they imagine they can easily undersell the older firm by 10 or 15 per cent., this, say, being the amount it costs to sell. Perhaps the eyes of some will be opened by these remarks; at any rate we sincerely trust those who think of underselling their trade competitors will think seriously over the matter before taking a leap which may prove to be too much a "leap in the dark."

ELECTRO-METALLURGY.

The subject of electro-metallurgy, taking this term in its widest signification, is of considerable importance actually, and of immense importance prospectively, not only to manufacturers of dynamo machines but to the rising generation of professional electricians, in whose hands it places almost unlimited opportunities for useful work. It is, however, one which has been, comparatively speaking, neglected by scientific journalism; for, even in the columns of the short-lived *Electro-Metallurgist*, little or no attention was given to such wide applications as those of the electrolytic refining of metals, treatment of ores, and manufacture of chemical products; and the above-mentioned term was apparently taken in its limited sense of the electro-deposition of metals for protective and ornamental purposes. We think it probable that this neglect, justified in some cases by the system of secrecy which has prevailed in certain works—as for instance in those of the *Norddeutsche Affinerie* at Hamburg—has reacted injuriously on the applications in question, by depriving them of the interest and initiative they might otherwise have awakened, and rendering impossible any useful suggestion on the part of the theoretical electro-chemist or the electrical engineer. We have heard of cases where some such suggestion might have entirely altered the aspect of affairs—where, for instance, energy was expended in converting a *ferric* into a *ferrous* salt at the cathode and in undoing this work at the anode, or where the practical advantage of equalising the resistances of the dynamo and of the external portion of the circuit was entirely lost sight of. For these and other reasons, we are fully disposed to devote some portion of our space to the consideration and discussion of those applications in which electro-chemistry is involved, and which have hitherto been generally regarded as being of too tentative a character to be compared in interest with such applications as telegraphy and electric lighting.

The treatment of this subject might advantageously, we think, be commenced by certain eliminations—by examining in what directions anything like an industrial application on a large scale would appear to be clearly prohibited by theoretical considerations, *i.e.*, by ascertained facts which have been generalised into laws. The waste of energy and

means in directions which to some may appear full of promise, but which investigation has already shown to be hopeless, the negative work which is more detrimental than inactivity, is above all things to be deprecated and avoided. From it, however, when consummated, may be obtained useful warnings, even more emphatic than those of theory; and the record of past failures is often more interesting than that of past successes, since it leaves open the path of future progress whilst indicating the directions to be avoided.

In regard to the amount of attention and space which will be devoted to the subjects referred to, we shall of course be guided by circumstances. We can do but little, comparatively, without the co-operation of recognized authorities in the domain of electro-chemistry and of practical workers therein; and one of our objects in penning the present article is to invite and secure such co-operation.

ELECTRIC LIGHTING OF THE CITY.

At the meeting of the Commissioners of Sewers, held at the Guildhall on Tuesday,

Mr. BRIDGMAN brought up a report of the Streets Committee, recommending that the proposed contract with the Anglo-American Brush Electric Light Corporation, for lighting a district of the City by means of electricity, be not further proceeded with. He said this report was in consequence of the important statements and proposals submitted to the Court when the question was last discussed. The committee cousidered it necessrry to inquire into those proposals, and before doing so, they would like to clear the ground. He hoped the Court would not take this to mean that they intended to shelve the question, for such was not the case. Hitherto they had proceeded on wrong lines. The committee hoped to lay down certain conditions on which the various companies would be asked to give a price, then they would be able to judge which would be the most satisfactory proposal. The committee were anxious that no time should be lost.

Mr. C. T. HARRIS could not quite agree that the report was in consequence of proposals made at the previous Court. It was in consequence of the belief that the proposed contract with the Brush Company was wrong in principle and did not protect the rights of the City. It was never intended by Act of Parliament that the Commission should have power to grant a monopoly, but simply a prohibitory power. The only proper way was to go to the Board of Trade and get a license for seven years.

Mr. TRELOAR hoped the committee would take this matter into consideration at once.

Mr. J. C. BELL was very sorry to see this report brought up by the Streets Committee. They had got a new Streets Committee, who would take some time to master the difficulties of an electric lighting contract. There was only one company with a backbone able to carry out such a work as this

Mr. MORTON said the committee were in favour of electric lighting if it could be obtained on terms fair and just to the citizens.

Mr. BRIDGMAN said all they undertook to do was to make inquiry, and it might be that the Brush Company's proposal would be the best.

The report was adopted.

Telephony.—It is stated that telephonic communication between Vienna and Prague and between Prague and Brunn will be opened in the course of the year.

ELECTROLYTIC DISINFECTION OF CRUDE ALCOHOLS.

Some interesting information as to the processes employed in France for the disinfection, prior to rectification, of the "low wines" obtained by the distillation of fermented extracts, obtained from a variety of vegetable substances containing sugar or starch, has been given by M. Ponthière, of the University of Louvain. By means of the electrolytic process of M. Naudin, the alcohol obtained from beet, for instance, affords on rectification a spirit free from the very objectionable flavour which usually characterises the spirits from this source, whilst the "low wines" obtained from the *topinambour*, or Jerusalem artichoke, which otherwise it would be impossible to utilise, afford by this method a spirit equal to that obtained from maize.

The first attempt in this direction, the process of M. Eisenmann, did not bring electrolysis into play, although it involved the use of electricity. This inventor passed a stream of ozonised air through the liquid to be disinfected, at a temperature of 70deg. Cent. The ozone is produced by passing air through a glass tube placed between two armatures which are in contact with the poles of an induction coil. Although certain deleterious constituents of the liquid are oxidised by this process, it has apparently no effect upon the aldehydes which are the principal impurity in the crude spirits to be treated.

According to the process of M. Naudin, the liquid is first hydrogenated by means of the zinc-copper couple of Gladstone and Tribe. In the installation of M. Boulet at Bapaume-lez-Rouen, tanks of wood or of iron, containing a number of zinc plates, alternately flat and corrugated, are employed; the weight of zinc in a tank of 150 hectolitres* being 6,200 kilos., the number of sheets 105, and the hydrogenising surface 1,800 sq. metres. Copper is deposited on the zinc from the sulphate of the metal, which is dissolved in the weak spirit to be purified. Five solutions containing ½ per cent. of the salt are successively employed; the total weight of sulphate of copper decomposed being 20 kilos. per 100 sq. metres of zinc surface, or 360 kilos. for the tank of 150 hectolitres.

The temperature at which the deposition of the copper is effected is a point of importance; it should range from 30deg. to 35deg Cent. Below 5deg. the action soon ceases; above 35deg. it is too violent, and the copper is non-adherent. The deposition of copper from each solution takes 24 hours, five days being thus required to form the zinc-copper couple, at the end of which time the deposit is of a chocolate-brown colour. The "low wines" to be treated are run into the tank from above, and are withdrawn through a tap at the lower portion of the tank into a reservoir, after remaining exposed to the action of hydrogen from six to 48 hours, according to the amount of the aldehyde (*al*cohol *dehyd*rogenated) contained in them.

By the action of the zinc-copper couple, hydrated oxide of zinc is produced, and this must be removed about every eight days by the addition of about 5 kilos. of hydrochloric acid to a charge of 150 hectolitres of "low wines." After each treatment with acid a charge of 150 hectrolitres containing 5 kilos. of sulphate of copper is introduced into the apparatus. By this means the latter may be kept in working order for 18 months or two years. The treatment of the crude spirit by the zinc-copper couple ordinarily suffices for its disinfection by the conversion, through the action of hydrogen, of the whole of the aldehydes into their corresponding alcohols; but in certain cases it is advisable, in consequence of the presence of other impurities, to subject the fluid to electrolysis prior to rectification.

The voltameters in which this electrolysis is effected are composed of cylindrical glass vessels 125 millimetres in diameter and 600 mm. high, provided with ebonite covers, through which pass an ingress and an exit tube, and two electrodes of sheet copper. This apparatus is, in our view, susceptible of being greatly perfected. For the treatment of 300 hectolitres of "low wines" in 24 hours, M. Naudin employs 12 of these voltameters, arranged 2 in series and 6 in parallel; the liquid passing through them in two parallel streams. The following are the conditions of the treatment:

* The hectolitre is 22 gallons, the kilogram 2·2lb.

Degree of acidulation of the liquid by hydrochloric acid (in volumes)	$\frac{3}{10000}$
Total current	36·65 amperes
Difference of potentials at the voltameter terminals (two in series)	113·5 volts
Current through each voltameter............	6·12 amperes
Resistance of " "	9·3 ohms

The current is supplied by a Siemens' shunt dynamo absorbing 4 h.-p.

To effect the neutralisation of the small quantity of acid employed, a quantity of zinc is placed in the supply tank of the rectifying still.

The following details have been given by M. Naudin as to the cost, per hectolitre of alcohol produced, of each of the above operations :—

Treatment of 200 hectolitres of "low wines" by the copper-zinc couple (in 24 hours).

Commercial hydrochloric acid. 1·25 kilo. at 6fr. per 100 kilos.	0·075 fr.
Sulphate of copper. 1·25 kilos. at 56fr. per 100 kilo..	0·70 "
Zinc consumed {by acid or sulph. of copper, 2 kilos. ... by disengagement of H, 1·5 kilos.} at 60fr.	2·10 "
Labour, 24 hours	7·00 "
Motive power...	2·00 "
Maintenance and repairs	1·50 "
Amortisation of 15,000fr. in 10 years	4·50 "
Total........................	17·875 fr.

Electrolysation of 200 hectolitres of "low wines."

Hydrochloric acid $\frac{3}{10000}$ = 6 litres	0·438 fr.
Zinc to neutralise acid, 4·5 kilos.	2·61 "
Motive power, 4 h.-p.	8·00 "
Labour, 24 hours..	7·00 "
Maintenance and repairs	1·50 "
Amortisation of 15,000fr. in 10 years	4·50 "
Total........................	24·048 fr.

CORRESPONDENCE.

CENTRAL STATION LIGHTING AT BERLIN.

To the Editor of The Electrical Engineer.

Sir,—In the notes of your last issue of the 2nd March, under the title "Berlin," quoted from *Industries*, description of our central station (No. 37, New Friedrichstrasse), the readers of your valuable journal are misled by the statement.

The Babcock boilers were made in Glasgow and not in Küstrin; besides two Davey-Paxman's compound engines of 35 effective h.-p. each, there is one 10 h.-p. of the same firm; the two dynamos of Mather and Platt are not of 18 kilo watts, but of 20 kilo watts each; the accumulators are de Khotinsky patent, and not pattern; their capacity 1,200 ampere-hours and not 600. This central station is made for 1,250 incandescent lamps of 150 volts 16 c.-p., and not for 500 lamps, and the lamps are "de Khotinsky" and not "Seels." All complete cost £4,000 instead of £3,500 mentioned, which will make per lamp £3 2s. instead of £7 stated by *Industries*.—Yours, &c.,

Capt. A. de Khotinsky.

ALTERNATING CURRENT ELECTRIC MOTORS.*

BY DR. LOUIS DUNCAN.

The alternating system of electrical distribution, possessing as it does many advantages for distributing electrical energy over extended areas, possesses certain disadvantages, among others that of not, at present, allowing the use of electric motors for the distribution of power. Let us, before taking up the special subject for consideration to-night, briefly review the general subject of alternating current distribution.

* Paper read before the American Institute of Electrical Engineers, February 14, 1888.

In this system are employed currents of high and constant potential, varying from positive to negative many times a second. If we represent current and potential by curves whose heights above a horizontal line represent amperes or volts, the horizontal distance representing intervals of time, we will have something like the following: Fig. 1, I representing current, II representing electromotive force; the maximum value of the current lagging behind the maximum of E.M.F, in a way that you were shown recently by Mr. Stanley.

The high potential used in the dynamo or primary circuit would not be suitable for incandescent lighting and would be dangerous; it is, therefore, reduced to a low potential at points of consumption by "transformers;" that is, induction coils working backward. Now, the whole beauty of the system lies in this—that by using high potentials in the primary circuits we can transmit a great deal of energy with comparatively little current, and, therefore, with little loss in the lines. This enables us to use small conductors, and to avoid the large investment in copper necessary in distributing energy by the direct system.

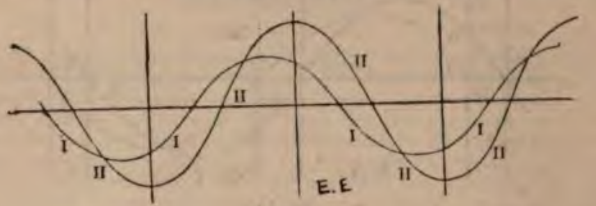


Fig. 1.

In any central station supplying electric lights, the full capacity of the plant is utilised but a short time during the day; and taking the whole twenty-four hours we will find that we have sold an amount of energy equal to a half or a third—perhaps even less—of the amount we could supply, supposing there was a demand for it all. Let us represent by a curve, Fig. 2, the amount of current used during the day in a constant potential system; the potential being constant, the energy will vary with the current, it being equal to C E.

The amount of energy we could have sold is represented by the total area A O X B; the amount we have sold is the area D E F G H I X O. If we had been able we would have three times the receipts, with expenses perhaps half again as much as in the first case.

A great problem before electricians is to fill the vacant spaces, A D E F G H A and H I B. There are two ways to partially accomplish this. Suppose, in the first place, we put electric motors on the circuits and sell power during the day. What effect will that have on our diagram? If the motors are at work from 7 a.m. to 6 p.m. we can sell so much power as will at no time make the sum of the power and the energy used for lights greater than the maximum capacity of our station. The area representing the power we can thus sell is shown by G K h m on the diagram. The total solid part of the diagram is all that an alternating system can supply; the direct system could fill the entire area by using storage batteries.

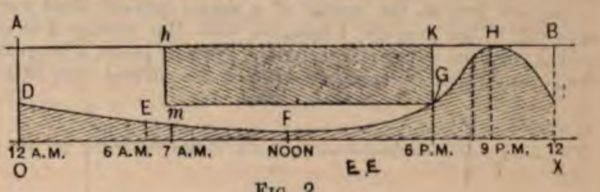


Fig. 2.

Our knowledge on the subject of alternating currents is largely due to the work of M. Joubert and Dr. John Hopkinson The latter showed first that alternating dynamos could be coupled in parallel, and afterwards that one dynamo could be used to drive another as a motor. He brought forward experiments tried by Prof. Adams and himself, in which one dynamo had driven another, the latter doing mechanical work. Mr. Siemens at the same time, in 1885, described experiments where he had driven both alternating dynamos and ordinary series motors by alternating currents. Dr. Hopkinson's mathematical work assumes that the curve representing E.M.F. is a simple sine curve; that is, that $E = E_0 \sin 2\pi \frac{t}{T}$; it is important to notice, however, that his principal conclusions do not depend upon this assumption, but would be true if the E.M.F. were any periodic curve. Since that time nothing of importance has appeared on the subject excepting two short papers, one by Mr. Kapp on "The Maximum Work Obtainable from a Given Source of E.M.F.;" the other by Mr. Blakesley on "Conditions of Maximum Efficiency in the Case of Transmission of Power by Alternating Electric Currents."

In all of the mathematical work done on this subject it has been assumed that the various E.M.F.'s may be represented by a sine curve, and that only simple electro-magnetic actions enter into the problem. I do not believe that these assumptions are

true. Since Joubert's experiments, made in 1881, it has been known that the curve of E.M.F. of a Siemens alternating dynamo, where the external circuit had no statical capacity, was very nearly a sine curve. With some of the machines used to-day, and under the much more complicated conditions of distribution, this is probably not even approximately true. Neither is it true that the statical actions of the different forms of wire upon each other in the transformers can be neglected. Messrs. Hutchinson, Wilkes, and myself have lately experimented on this subject, and we have obtained the curves for the currents in the secondary and primary circuits under many conditions. These observed results do not agree with the results of calculation in the few cases that we have worked out. Until we have fully satisfied ourselves in this matter I will avoid any but the simplest mathematical work.

Alternating current motors are not in successful use. Let us try to find out the difficulties they present, and attempt to suggest plans for overcoming them.

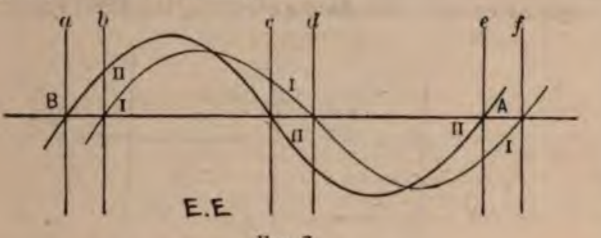


FIG. 3.

The energy being transformed at any moment in any dynamo-electric apparatus—in which I include dynamos, motors, transformers, &c.—is equal to the product of the current by the electromotive force produced by the apparatus. In a dynamo, for example, the amount of mechanical energy being transformed into electrical is E C, where E is the electromotive force produced by the dynamo; in a motor the electrical work transformed into mechanical is e C, where e again is the E.M.F. produced by the apparatus, the counter E.M.F. of the motor. This is true for alternating as well as for direct current apparatus. Generally we have:

Work = E C. This is + for a dynamo − for a motor.

In alternating circuits E and C are constantly changing. If we represent them by curves, as before, we must multiply each value of C by the corresponding value of E, and if we add all these together from A to B, Fig. 3, we will have the work done by the current in one period. Now if we consider values above the horizontal + and below it −, we have from e to d a + value of the product, from c to d a − value, from c to b a + value, from b to a −. The total work done then is [e to d]+[c to b]−[d to c]−[b to a].

Now we see that if we shift I I forward or pull I back, we have this work less even, though the curves themselves remain the same size. Now this is one of the exceptions I take to the alternating system. In a direct system as the work decreases the current decreases, and the heating of the mains becomes proportionally less, since it varies as C^2; for example, if the maximum loss in the mains of a direct current plant were 10 per cent. of the average, I imagine that the average loss is not over 3 per cent. In an alternating current plant, a decrease in the consumption of energy decreases the current very little; it

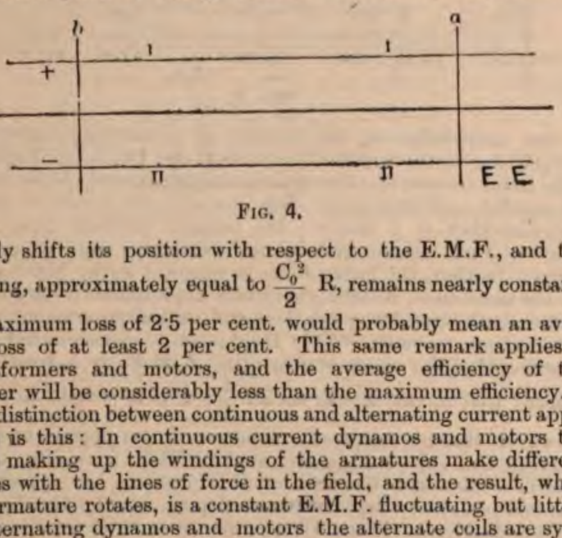


FIG. 4.

simply shifts its position with respect to the E.M.F., and the heating, approximately equal to $\frac{C_0^2}{2}$ R, remains nearly constant. A maximum loss of 2·5 per cent. would probably mean an average loss of at least 2 per cent. This same remark applies to transformers and motors, and the average efficiency of the former will be considerably less than the maximum efficiency.

A distinction between continuous and alternating current apparatus is this: In continuous current dynamos and motors the cores making up the windings of the armatures make different angles with the lines of force in the field, and the result, when the armature rotates, is a constant E.M.F. fluctuating but little; in alternating dynamos and motors the alternate coils are symmetrical with respect to the alternate poles, the remaining coils being symmetrical with respect to similar poles of opposite signs. The result is a varying E.M.F., changing as has been shown. In dynamos the effect of this is that the power applied either varies from zero to a maximum each period, or the armature changes its speed at different points and oscillates with a period equal to that of the E.M.F.

Let us now consider what takes place in the case of two motors, one continuous, the other alternating, one between mains where a constant continuous E.M.F. is maintained, the other where there is a constant alternating E.M.F. In the first case representing current and E.M.F. by curves, as we have been doing, we will have two straight lines, Fig. 4, one above, the other below our horizontal axis, the former representing current, the latter the counter E.M.F. of the motor. Reckoning time along the axis we have for the energy transformed in the interval from a to b = − C E. As this is − it means that electrical is transformed into mechanical work.

Now, let us consider an alternating current motor built like an alternating dynamo, the field excited by a continuous current. If A B C, Fig. 5, are the poles of the field magnets, supposed to be excited by a continuous current, then the curve I I will represent the counter or motor E.M.F. If our motor is running slowly there will be two or three reversals of current in the time it takes a coil to go from A to B, Fig. 6, and the product C E will be nearly zero, the positive and negative parts being

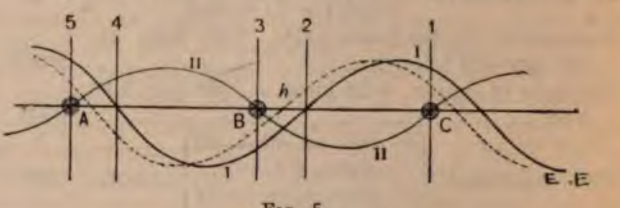


FIG. 5.

almost equal. Whether it is + or − is somewhat a matter of chance, and if it is − from A to B it will very likely be + from B to C. Thus the armature is pushed first in one direction, then in the opposite, and there is no definite tendency for it to rotate as a motor. This brings us to our first difficulty, a simple alternating current motor will not start itself. Let us suppose, however, that it has been started by some means and has reached such a speed that in the time of a reversal a coil shall have moved over the distance between two similar poles. We will have the state of things in Fig. 5, and the armature will continue to rotate. Now, the position of the curve I I is fixed. We will consider the position of I as determined by the position of the armature coils when the current in them is zero: for instance, if the speed increases a little the curve will advance as shown by the dotted line. The total work transformed is the product of the two curves; from 1 to 2 it is −, from 2 to 3 it is +, from 3 to 4 −, from 4 to 5 +. The result is −[1 to 2+3 to 4]+[2 to 3+4 to 5]; part of the time then the machine is working as a dynamo, part of the time as a motor; the difference of the values represented by the brackets gives the mechanical work that is really available. Now, while the available work is the difference of these areas, the difference becoming small as the load is decreased, the heating is the *sum* C^2 R for all the values of the current, and is independent of the position of its curve, as has been pointed out above.

Looking at the figure again we see that from 1 to 2 the armature is pushed forward by the current in the line; from 2 to 3 it is pulled back, since it is acting as a dynamo feeding into the line and can only get the energy to produce the current by decreasing its speed and drawing from its energy of motion. The armature oscillates then, and it is evident that the amount of

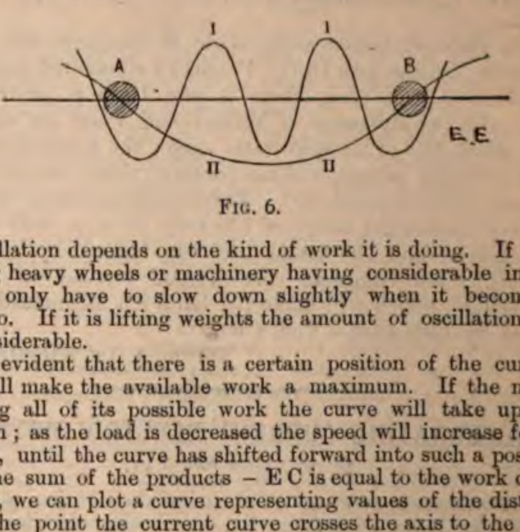


FIG. 6.

its oscillation depends on the kind of work it is doing. If it is driving heavy wheels or machinery having considerable inertia it will only have to slow down slightly when it becomes a dynamo. If it is lifting weights the amount of oscillation will be considerable.

It is evident that there is a certain position of the curve I that will make the available work a maximum. If the motor is doing all of its possible work the curve will take up this position; as the load is decreased the speed will increase for an instant, until the curve has shifted forward into such a position that the sum of the products − E C is equal to the work done. In fact, we can plot a curve representing values of the distance from the point the current curve crosses the axis to the same point when the work is zero corresponding to different loads.

Now the value of this lag, as we will call it, cannot be greater than O P, Fig. 7, for although we might extend our curve on the other side, yet a slight increase in our load will cause the armature to fall back, decreasing the available work, and suddenly stop. It is, in fact, in unstable equilibrium.

Suppose we have found the value of the lag that will give us

a maximum value of the work, and have calculated this value by the ordinary mathematical methods employed, the real work we can obtain is less than this, for the current curve oscillates on both sides of the maximum, supposing we *could* work at the maximum; that is, it is only for a very short time in the best position; so that if we take the sum of the work for a period, it will be less than the calculated maximum. In reality we must work slightly in advance of the maximum, for if we were too near it the curve would fall behind P, and will then be in unstable equilibrium and stop. The practical maximum will then vary according to the amount of the oscillation; that is, according to the nature of the work being down.

It seems to me that the possible forms of alternating motors are: (1) Ordinary series motor; (2) an alternating dynamo reversed, the field being excited by a continuous current; (3) an alternating dynamo reversed, the field being excited by the alternating current first corrected by a commutator on the shaft; (4) the arrangement suggested by Professor Thomson, which is described below.

FIG. 7.

In the first type—a series motor—there is no difficulty in starting; the motor will start of itself. There are these troubles, however: the armature and field must both be thoroughly laminated to prevent eddy currents; the magnetism of such large masses of iron being rapidly reversed will cause losses, unless both field and armature are far from saturation—that is, the mass must be great. Again, Mr. Kapp has shown that to obtain the maximum work we must have, approximately, the counter E.M.F. of the motor equal to the E.M.F. of self-induction—a condition almost impossible to realise in practice. The motor must be governed in some way, as it will not govern itself.

The alternating motor with a field fed from the alternating circuit, the current being commutated, will start itself. I do not know if this has been generally recognised. If, in Fig. 8, A and B are poles, and C one of the armature coils, the effects of the currents will be as shown by the two sets of signs. The effect of either arrangement is to move the armature in the direction of the arrow. When C gets opposite A the commutator changes the relative directions of the currents in C and A, and C is repelled by A and the armature continues to rotate. The maximum work will, I think, be done when the speed is such that a reversal takes place in a distance A to B. The mathematical investigation is difficult, and until I am satisfied as to the assumptions usually made I will not attempt it. We have as an advantage of this type that it will start itself; a disadvantage is that the fields must be carefully laminated, there is loss in reversing them, and there will be for some speeds considerable sparking at the field commutator. I should not imagine, either, that the work obtainable from such a motor would be as great as if its field were fed by continuous currents.

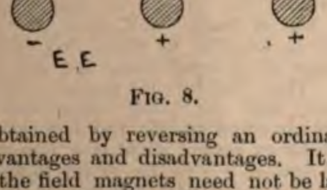


FIG. 8.

The motor obtained by reversing an ordinary alternating dynamo has advantages and disadvantages. It perfectly regulates itself, and the field magnets need not be laminated; that is, it can be made cheaply. It will give a greater output from a given source of current than corresponding machines of either of the types already discussed. Its disadvantages are that it must be started independently. We must have a continuous current to excite the field, and, if a load having any considerable inertia be suddenly applied, the motor will stop. This last objection, by the way, will apply to the type of motor previously discussed; provided, as I have supposed, the maximum work is obtainable when the counter E.M.F. has same period as the applied E.M.F.

Let us see what means we can employ to start the motor and excite the field. We could start by passing the commutated alternating current through the field as in the second type of motor discussed, changing our connections when the proper speed is attained, so that a continuous current from some external source passes through the field and the alternating current is shut off from it. Another way would be to have on the same shaft with our main motor a motor arrangement such as was described by Prof. Elihu Thomson in his valuable paper on alternating current phenomena, read before the Institute. With this arrangement we can do more than start the motor. Prof. Thomson pointed out that when this auxiliary motor reached a certain speed it would produce a continuous current in the external circuit of its armature. This current could be used to excite the field of the main motor. By properly proportioning the number of coils in the main and auxiliary motors, this continuous current would be produced just when the motor had arrived at its proper speed, and it is evident that we can make this current operate an automatic device to make the circuit of the main motor at this moment. I should imagine, however, that a motor made in this way would be expensive and not particularly efficient.

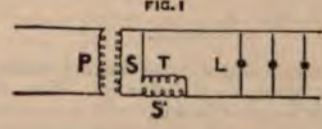
(To be continued.)

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of the Society of Telegraph-Engineers on the 16th ult. (Mr. W. H. Preece, presiding), the discussion was commenced on the papers of Messrs. Kapp and Mackenzie on "Transformers."

Prof. Ayrton agreed with Mr. Mackenzie that credit was due to Messrs. Gaulard and Gibbs for having drawn attention to the method of distributing electrical energy at the Aquarium Exhibition of 1882. No one who had seen the secondary generator at the Aquarium would have thought in a short time this system would be so largely used for the distribution of electrical energy in the country. Probably some did not appreciate the use of transformers, because the measurements that they had seen were unsatisfactorily made. Even the system might be as deficient in satisfaction as the way used for measuring its efficiency. Of course, the speaker remarked, that in no manner lessened the value of transformers. For example, the potential difference at the terminals of the transformer was measured by a high-resistance dynamometer, and that was measured by the current measured by a low-resistance dynamometer, and the conclusion at once was that the product measured either the watts put in or the watts given out, and in this way an efficiency was arrived at, which might or might not have some connection with the true efficiency of the transformer. In this experiment two errors were made, viz., to measure alternating volts with a high-resistance dynamometer was wrong, and to multiply the volts, even were they measured correctly, by the current would not give the watts if the circuit contained self or mutual induction, any more than the mean pressure of the steam in a cylinder multiplied by the number of revolutions per minute gave an answer proportional to the horse-power given by the engine independent of the time the steam was cut off at each stroke. Nevertheless, it did seem that the system was an extremely good one, the fact being proved by the extensive use of it in the United States. The next point in consideration was the danger of lives in touching the secondary, which might easily be avoided by putting one wire of every secondary to earth, without affecting the primary circuits in the least, whilst it ensured perfect safety in the secondary arrangement without the use of any particular fuses or automatic motive device. It also had this advantage—that it prevented their getting a shock from the electrostatic capacity of a transformer, which might be considerable. It had been rather held by the authors of the papers that it was impossible to use transformers *in series* if they wished to maintain constant potential difference at the terminals of the secondary when the resistance of the secondary circuit was altered; that is to say, if the number of lamps in parallel in the secondary circuit was varied. There was, however, a method of producing a constant potential difference in the secondary with constant (mean alternating) current in the primary, which it appeared to him would lead to good

FIG. I



results. The method was analogous with the compound-wound dynamo. In a compound wound dynamo they had a series coil, which increased the magnetisation of the field-magnet when the current of the outside circuit was increased. They could get exactly the same thing with transformers. Supposing the secondary coil S (Fig. 1) were joined in the ordinary way to the lamps L, let there be in addition a second induction coil, S' T, the primary of which S' was in series with S and the secondary T, so joined up that it added a potential difference to the secondary circuit and added the greater potential difference the greater the current passing through the secondary. That arrangement was exactly the arrangement of a compound-wound dynamo; the tertiary coil would correspond to the series coil of the compound-wound dynamo. That was to say, a constant current passing through the primary coil P, would produce a constant electromotive force in the secondary S, and a potential difference would be added to the secondary circuit, the added potential difference being the greater the greater the current in the secondary circuit S. At any rate, he believed it might be possible by such an arrangement to do this, and so obtain a transformer capable of working in series. That idea occurred to his colleague and himself some three or four years ago, but as they found great difficulty in working out the currents in the primary, secondary and tertiary coils mathematically, they thought they should do better by resorting to experiments. An apparatus

KAPP AND SNELL TRANSFORMER.

Experiments made at the Central Institution by Messrs. DYKES, LAMB, PRIEST, SMITH, and ZINGLER.

Primary.		Secondary.		Calorimeter.	Watts given out by Secondary.	Watts given to Primary.			Efficiency.		
a Volts.	b Amperes.	d Volts.	f Amperes.	g Watts wasted in Heat.	$h=\sqrt{d^2\times f^2}$	$g+h$ True.	$\sqrt{a^2\times b^2}$	j by Watt-meter.	$\frac{100\,h}{g\times h}$ True.	$\frac{100\,h}{\sqrt{a^2\times b^2}}$	$\frac{100\,h}{j}$
184·3	0·8	94·5	0	53 18	0	53·18	147·2	98·5	0	0	0
184·6	2·3	96·8	3·3	79·05	318·7	397·8	424·5	446·7	80·1	75·1	71·4
187·6	3·32	97·7	5·09	82·63	495·6	577·9	623·7	653·2	85·8	79·5	75·9
186·1	8·31	94·3	14·87	55·6	1416	1472	1546	1727	96·2	91·5	82
185·6	16·14	91·44	30·59	149 9	2813	2963	2995	3277	95·0	93·9	85·9

Each test given in the above table is the mean of five or six consistent results.

Efficiency $\frac{100\,h}{\sqrt{a^2\times b^2}}$ neglects the lag due to the self and mutual induction of the transformer.

Efficiency $\frac{100\,h}{j}$ neglects the lag due to the self and mutual induction of the transformer ; also the lag in the fine wire coil of the watt meter due to its self induction.

Time of an alternation in all the experiments was about $\frac{1}{180}$th of a second.

was made, and, indeed, it was for these experiments that the little voltmeter which they brought before the Society at the end of last year was originally devised. Their transformers were little things, and so they found it was necessary to measure a few volts—alternate potential difference—accurately, and therefore they wanted a voltmeter to measure four or five alternate volts accurately. When their experiments were about to start he came across an account published, if he remembered rightly, by Messrs. Gaulard and Gibbs, putting forward exactly the same device which those gentlemen had then just covered by a patent. He would be very glad to hear from Mr. Mackenzie whether this system was seriously tried. Had he not come across this description of a precisely similar method of compounding transformers, he and his colleague would certainly have pursued the matter, but they left Messrs. Gaulard and Gibbs to do it, and, curiously enough, nothing more had been heard of it. He was very glad to see that the idea of magnetic lag, which means a retardation of iron to be magnetised, was gradually gaining acceptance, especially in consequence of the admirable work that had been done on this subject by Prof. Ewing. The idea of magnetic lag, quite apart from Foucault currents in the iron, was put forward some years ago in that room in the paper, prepared by himself and his colleague, on electromotors and their government, and the conception was used in all the calculations they made. This conception was somewhat laughed at by writers in some standard books. Their names were held out to reproach as having brought forward an idea of a magnetic lag which was something different from a lag due to Foucault currents, and which could not be entirely removed by any amount of lamination. Now, however, that the Greek name *hysteresis* had been given to the lag, the classically-educated Englishman was willing to believe in it.

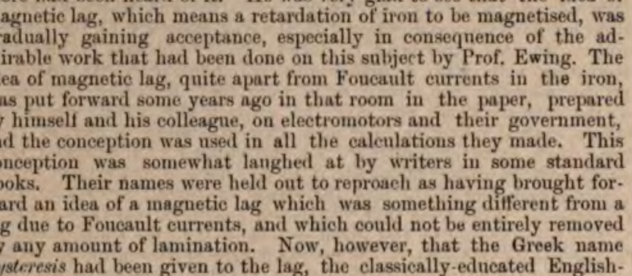


FIG. 2.

He had spoken about wrong ways of making measurements of the efficiency and power given to transformers. Now, he would say a word about the right ways of making such measurements. He was interested in doing this because, through the kindness of Mr. Kapp, who had lent him one of his transformers some time ago, a considerable number of experiments had been made by the third-year students at the Central Institution during the past few weeks. The students had worked at the subject with the most laudable perseverance, in spite of the very considerable number of difficulties which they had to overcome. There was only, as far as he knew, one electric method for measuring the power given to a circuit which contained self or mutual induction. The method was a method employing the quadrant electrometer. It was a method which Dr. Hopkinson employed in measuring the efficiency of Gaulard and Gibbs' transformers on the Underground Railway some few years ago. Let A B (Fig. 2) be the circuit possessing self or mutual induction, or both, the power given to which it is desired to measure. Place in series with this a *non-inductive* resistance, B C, of known value r ohms, and send a current through the two by means of the dynamo D. Join the pairs of quadrants of an electrometer to the points A and B, and the needle to C ; then if A, B, and C represent the potentials at any moment of the three points, and if D be the steady deflection of the electrometer

$$D=\frac{k}{2\tau}\int_0^{2\tau}(A-B)\left(C-\frac{A+B}{2}\right)dt,$$

where τ is the interval between two alternations. Next, join the needle to the point B, and let a steady deflection, d, of the electrometer be now obtained ; then

$$d=\frac{k}{2\tau}\int_0^{2\tau}(A-B)\left(B-\frac{A+B}{2}\right)dt.$$

Consequently,

$$\frac{D-d}{r\,k}=\frac{1}{2\,\tau}\int_0^{\cdot\tau}(A-B)\left(\frac{B-C}{r}\right)dt.$$

Now the expression on the right hand side is the mean value of the true watts given to the circuit A B, therefore $\frac{D-d}{r\,k}$ measures this mean value of the true watts.

It was rather interesting, because this method occurred simultaneously to Prof. Fitzgerald, of Dublin, and to the speaker during the Paris Electrical Congress of 1881, while listening to M. Joubert's paper on the measurement of alternating volts with an electrometer, which, of course, was a very much simpler thing. The use of the electrometer to measure volts only did what a Cardew voltmeter would do. The use of an electrometer to measure power, given by an alternating current to a circuit possessing self or mutual induction, did what no other instrument would do. But though the method was theoretically perfect, it had distinct practical objections. The first objection was that another resistance B C (Fig. 2) had to be put in series with the conductor A B, in which the power expended was to be measured, and, of course, a certain amount of power was wasted in this wire, B C. That did not interfere with the accuracy of the experiment in any way, but it might be inconvenient to have to waste any power in a circuit previously worked up to its limit. But there was another more serious objection which he was not aware of up to the last couple of years. Their formula was worked out on the assumption that the ordinary law of the electrometer, as given, for example, by Clerk Maxwell, was true. The law of the electrometer, as given by Clerk Maxwell, was that the deflection of the needle of an electrometer was proportional to the difference of potentials between the quadrants multiplied by a term containing the potential of the needle, minus half the sum of the potentials of the quadrants. Unfortunately, as experiments made at the Central Institution had shown, it was an exception for any given electrometer to satisfy this formula. He would not go more into that at the present time, because it would form the subject of a subsequent communication. He merely wished to warn any of them who were going to use the electrometer that, although this method was perfect on the assumption that the formula given in books was the formula for the electrometer, it naturally was not so perfect if the formula was wrong ; so that even this method, pretty as it was, was at fault. Well, then, there was only one other method that he knew of by which they could measure the power and efficiency of a transformer, and that was the calorimetric method. They wanted to measure the power given to the transformer, and the power given out by the transformer. The power given out by the transformers could be easily measured. The secondary circuit would give current to, say, incandescent lamps, and as there was no lag in this part of the circuit the power could be measured merely with a voltmeter and dynamometer. But they could not employ that method to find the power given to the primary. They could, however, do it indirectly in this way :—Put the transformer in a calorimeter ; first put it in a box, close it up water-tight, then put it in another box, which must be water-tight at the bottom, but need not be water-tight at the top ; arrange a definite resistance in the secondary circuit, and send a definite current through the transformer for a certain time, and allow water to enter, say, at the bottom of the calorimeter and to flow out at the top, and measure the temperature of the entering water with a thermometer and the temperature of the water which leaves, and keep the current flowing until everything has become quite steady—until the temperature of the water as it flows out of the calorimeter ceases to rise, which in some cases took as long as three and a half hours. Then, quite apart from the specific heat of the transformer and the calorimeter, and so on, they had at once the power wasted in the transformer. Supposing W was the weight of water in grammes which flowed out of the calorimeter in a time of, say, t seconds, and suppose T was the difference of tempe-

rature between the entering water and the leaving water, which he had supposed to have become quite steady, then the power in watts wasted in the trasformer and given out in the form of heat was equal to W, the number of grammes of water, multiplied by difference of temperature T divided by the time in seconds t into a constant ·239. That gave them the power in watts that was wasted in the transformer. That added, of course, to the power given out by the secondary, which was obtained by electrical measurement, gave them the power put into the primary, and they had then the whole measurement with a considerable amount of accuracy. Let him repeat, power given out by the secondary was accurately measured, provided that the secondary was attached to incandescent lamps or to something having no self-induction nor mutual induction, by the square root of the mean square of the volts multiplied by the square root of the mean square of the current; that was to say, measured by the reading of the Cardew voltmeter multiplied by the reading of the Siemens dynamometer. That was the power given out in watts. The power wasted was measured by the formula already given. The ratio of the watts obtained in secondary to the sum of the two is, of course, the efficiency. Well, that method had given them very fair results. He had compared these readings with those obtained by putting a dynamometer and a voltmeter on the primary circuit. For the interest of the thing, they had also an ordinary wattmeter in circuit, the thick coil in series with the primary, and the fine coil a shunt to the mains. Now, it was interesting to see the sort of results that were obtained on the different systems of measurement, especially as they knew which results were true and which results were more or less correct. In the first case, the circuit outside was broken—that is, there was no current in the secondary circuit. This particular transformer was an exact *fac simile* of a small transformer which Mr. Kapp had on the table last time. He might mention that Mr. Kapp's mode of rating transformers was an extremely satisfactory one. Very often when a new apparatus was devised the nominal power was stated in excess of what the real power was. But transformers, at any rate Messrs. Kapp and Snell's transformers, were on a par with the steam engine, and that was that the real power developed was far greater than the nominal. He did not know whether his dynamos were equally good; but if so they must be extremely good. This was the two horse-power transformer nominal, which did not mean, he was happy to say, that it gave one horse-power. It meant that you could get three out of it, or even four without undue heating (applause). In the first case the volts at the primary circuit were 184·3, the volts at the secondary—the circuit being open—were 94·5. Now let them see the enormous differences of the power as measured in the different ways. The watts put in as measured by the voltmeter and dynamometer were 147. The watts put in measured by the wattmeter were 98·5. But the actual power put into the whole circuit was only 53 watts. Therefore the two first were enormously too large; and they could see why they were too large. They were too large, because when the secondary circuit was broken, the effective self-induction of the primary coil of the transformer was very much larger than when the secondary circuit was closed, and the errors of both methods became immensely magnified. Of course, in this case, since the secondary was open, all the power put in was wasted in the heat. But the real watts given to the primary, as determined by the calorimeter, was 53·2. The other methods indicated, then, about from two to three times too much. Of course, as the secondary circuit was closed, and less and less resistance was put in, the readings given by the the wattmeter as well as the product of indications of the voltmeter and dynamometer became nearly equal to the true watts, but they never, even for the maximum power, became equal. For example, when 2,963 watts were actually being given to the transformer, which was about 4 h.-p., the product of the square root of mean square of volts into square root of mean square of amperes gave 2,995 watts, while the wattmeter gave 3,277 watts as the power put into the transformer. The readings obtained from the voltmeter and the dynamometer were higher than the true watts put in, because lag, due to the self and mutual induction of the transformer, was ignored altogether. The wattmeter readings were higher than the true watts put in, because not merely was the lag due to the self and mutual induction of the transformer neglected, but the lag in the fine wire coil of the wattmeter, due to its self-induction, was also ignored. That led him to investigate the question as to whether the wattmeter ought to give them an answer nearer the truth than the product of V squared into C squared; and the result that he had obtained, approximately at any rate, was this:—The wattmeter might or might not apparently give them an answer nearer or farther away from the truth than the reading from the dynamoter and the voltmeter. A rough calculation showed this was what was obtained with a wattmeter. Take a wattmeter like a Siemens wattmeter, which had practically no mutual induction, but had some self-induction; then if such a wattmeter were employed to measure power in a circuit having self-induction this seemed to him what would be obtained. If τ was the time of an alternation, r the resistance and L the coefficient of self-induction of the fine wire circuit of the wattmeter, r' and L′ the resistance and self-induction of the circuit the power given to which it was desired to measure, then the reading of the watt-meter, compared with the true power which they wanted to measure, had this value $\frac{r}{r'} \times \frac{\tau^2 r r' + \pi^2 L L'}{\tau^2 r^2 + \pi^2 L^2}$. It was possible, by putting but a few convolutions on the suspended fine wire coil of the wattmeter, and using for the greater part of the resistance of the fine wire circuit a stationary non-inductive resistance, to make L the coefficient of self-induction of the fine wire circuit of the wattmeter very small; but unless it were made absolutely nought, the term $\pi^2 L L'$ might be large in consequence of the largeness of L, and the expression would be the greater the greater L′ was. So that, in other words, they might expect when the circuit the power given to which they wished to measure had very much self-induction, that the wattmeter would give an answer far too high. In the wattmeter used at the Central Institution, the self-induction of the fine wire circuit was made very small in the way just indicated, the resistance of the suspended coil having only $\frac{1}{15}$th of the value of that of the non-inductive stationary coil; but still the watts given to the primary, as measured by the wattmeter, were 200 per cent. too large when the secondary circuit was open.

(*To be continued.*)

THE ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

HOUSE OF LORDS, MONDAY, MARCH 5.

Lord Thurlow, in moving the second reading of this Bill in the House of Lords, on Monday, the 5th inst., said that if he could have had an assurance from the Government that they would be willing to take this matter in hand he would not have troubled their lordships on the present occasion. He desired their lordships to regard this question from the point of view of health, of science, of more light, of safety, and of the preservation of property. The object of the Bill was to remove what had proved to be prohibitive restrictions upon an industry which was deserving of every support. The restrictions imposed by the Act of 1882 had acted very harshly. The President of the Board of Trade, replying last week to a question in the House of Commons, said that since the passing of the Electric Lighting Act of 1882, 59 provisional orders and five licences had been granted to companies and 15 provisional orders and two licences to local authorities. The President of the Board of Trade was not aware that in any single case where these powers had been obtained they had been exercised. Such was the crushing effect of the Electric Lighting Act of 1882. Still he wished to say a few words in praise of that measure, which it was the object of this Bill to amend in only one or two small but important particulars. The Act of 1882 was a most elaborate measure for dealing with a then almost unknown science. It successfully prescribed safeguards against dangers which had only since become manifest, and its object was to impose checks on rash and ill-considered schemes. It now only required trifling amendment to allow the industry to proceed, and he claimed that the time had arrived for action in that direction. In the United States there were over 120 electric light companies, paying dividends from 6 to 14 per cent., in Germany there were 604 companies, and in almost every large town in Italy electric lighting was making progress. It was only in England that the science was comparatively at a standstill, and he hoped that state of things would not be allowed to last much longer. The present time was propitious for several reasons. There never was a time when a larger amount of capital was lying idle or when there was a larger army of unemployed seeking work and finding none, and by passing this Bill lucrative work might immediately be provided for thousands of men, women, and children. He thought it would not be too much to call upon the Board of Trade to make incandescent electric lighting compulsory in all mines, factories, schools, churches, theatres, hospitals, and other places where human beings congregated together. He ventured to say that when such a demand was made the Government of the day would be neither willing nor able to resist it. Many of their lordships had no doubt visited factories lighted by gas full of toiling men, women and children from 6.30 a.m. to 6.30 p.m., and had noticed the vitiated state of the atmosphere. The difference between that and a factory lighted by electricity was manifest in a moment. It was like being transported suddenly to another planet. Workmen who had been employed in factories lighted with electricity had told him that nothing short of starvation would induce them to work again in factories lighted by gas. It was the same in the case of mines. Electric lighting would minimise the dangers which now occurred through naked lights or faulty lamps. Then, as to fires in the metropolis, Captain Shaw's report showed that the total number of fires in 1887 was 2,363, and no less than 671, or 30 per cent., were directly attributable to causes connected with existing systems of lighting. These figures did not include 691 fires, the origin of which was uncertain, and of these at least 30 per cent. might fairly be said to be due to the same cause. Then as to destruction and damage to property. Some of the first tradesmen in London had told him that they had effected great saving since they had substituted the electric light for gas in their showrooms and shops. It was also well known that the use of gas was very prejudicial to books, and the employment of electric light in libraries would be a great advantage. The Bill was precisely similar to the Bill which was passed by this House last Session, and it proposed to extend the licence granted by provisional order to any company from 21 years to 42 years. The period of 21 years fixed by the present Act was found to be too short, and to be insufficient to allow electric lighting companies to recoup themselves. The Board of Trade acceded to this view, and this extension of the life of the Provision Order would render the clauses with regard to the terms of purchase of less importance. He would, therefore, be willing to strike out of the Bill all reference to the purchase of "the goodwill," which, he understood, had hitherto been a stumbling block and a cause of opposition to the Bill. In bringing forward this measure he was solely actuated by a desire for the public interest. There existed at present a great want of employment, and yet, as was well known, there was a vast amount of capital waiting for investment. If the present Act was amended as this Bill proposed, he believed that £100,000,000 of capital would thereby find useful employment.

The Duke of Marlborough said the Bill did not appear to contain any regulations as to the laying down of the electric cables. At present these lines were growing in number, and were being run over everybody's houses without the assent or consent of householders, and he thought that it should be defined in any Bill dealing with this subject

what the rights of electric companies exactly were. There had, so far as he knew, been no decision in the law Courts upon the point. At present a quantity of telephone wires were to be seen running in every direction in the Metropolis. The cables for electric lighting would be still more dangerous. They would in time become a great nuisance, and if the Acts dealing with electric lighting were silent on the point it would hereafter be said that Parliament had unreservedly conferred on these companies the right of running these cables over houses as at present. In New York, where electric lighting was more developed than here, the electric companies were bound to place their cables underground. If it were found impossible to make a similar provision in this country, still some regulations ought to be made as to the course they should follow so as to prevent them crossing and recrossing public streets as at present.

The **Earl of Crawford and Balcarres** agreed that the Electric Lighting Act required amendment, but he thought they should deal in a thorough manner with this subject and not merely with a single clause. In 1882, when the first Act was passed, a determination was formed that the promoters of electric lighting schemes should not enjoy a monopoly, and it was accordingly resolved that when cables were laid in the street of any town by an electric company its work should be purchaseable by the local authority. Another provision of the Act laid down that no work should be undertaken by a company without licence from the Board of Trade or a special Act or a provisional order. These two provisions had been fatal to the measure. Licences and provisional orders had been applied for, but no work had been done. He suggested that the promoters of a scheme ought to be allowed to make their own arrangements with the local authority. Let the company pay rent for the use of the mains which they placed under the streets, and let them be absolved from the obligation of supplying light to every corner of a given district when there might be no chance of a reasonable return for their outlay. He looked forward to the day when companies would be able to lay their cables underground with a good prospect of success; but he asserted that the risks attending exposed electric mains were fewer than the risks which attended either telephone or telegraph wires. When snow fell upon an electric light main it inevitably melted, but it accumulated on other wires, with the result that serious accidents we e not uncommon. He hoped that the Bill before their lordships would be read a second time. Hereafter he intended to place before them a Bill of his own.

The **Earl of Onslow** said that the Bill as explained by the noble lord opposite was much less important than it was as printed. There was a clause in the Bill which covered a great deal of ground and repealed a provision of the existing Act; but he understood that when the Bill was considered in Committee the whole of that clause would be withdrawn, in order that to the term of 21 years during which provisional orders must now run a further term of 21 years might be added. The Bill, as it was amended, did not appear likely to be productive of great harm, and he was prepared to assent to the second reading on the conditions the noble lord had suggested. He did not know whether the reason named was the only reason why electric lighting had not been more extensively adopted; but there could be no doubt that public expectation had been greatly disappointed in the matter. We had all hoped that electric lighting would have been much more largely used. Whether it was on account of the limitation in the number of years allowed to companies or the fact that promoters found themselves unable to supply the electric light at prices that would compete with gas, or whether it was on account of difficulties in carrying out the supply of electricity he did not know; but of this he was certain, that if a small alteration in the law was likely to facilitate the adoption of the electric light in London and other large towns the Government would have no objection to it. He understood the noble earl behind to intimate that he would introduce another Bill, and if that was the noble earl's intention it would be well that they should be in possession of both Bills before this was considered in committee, and that both should be considered with reference to the provisions of the Bill of the Government dealing with local authorities, which would soon be produced in the other House and which must naturally affect the powers of local authorities.

Lord Herschell was not quite sure he understood what it was the Government was prepared to assent to. As far as he could gather, it was that the Act of 1882 was to be amended by substituting 42 years for 21 years. If no other alteration was to be made, he doubted much whether the Bill would have the effect desired. In this country we had not made the advance in electric lighting which had been made in other parts of the world. He had long desired to avail himself of this important improvement; but he had found it to be utterly impossible, for the reason that the Legislature had put impediments in the way of the spread of this invention which was not put in its way in any other country. He believed that in the South Sea Islands the electric light was more used than it was in London. This was not altogether to our credit. He quite sympathised with the desire to prevent undue interference with the control of local authorities, and it might be expedient to provide that local authorities should ultimately if they wished be allowed to become purchasers of electric lighting apparatus and to supply the electric light as they now supplied gas. He did not personally feel very strongly on that point; but he was not at all sure whether the balance of advantage was not against allowing municipal corporations to become trading bodies. With regard to the electric light there was danger in doing this, because in some cases their conduct might be affected by the fact that they were owners of a gas business, and the electric light would be a serious rival to gas. At all events, the power to acquire apparatus ought to be conferred in such a way as not to cripple the progress of invention and improvement. It was too much to ask the present generation to forego the advantages of electric lighting because their doing so might render it cheaper 30 or 40 years hence. He believed that the Indian Government might acquire Indian railways upon paying a price based upon the average value of the shares for the preceding seven years. It had been found that capitalists were prepared to risk capital on these terms, and possibly a similar arrangement might be found satisfactory to the promoters of electric lighting. He would urge the Government to consider whether on some such terms the adoption of electric lighting might be facilitated.

The **Marquis of Salisbury.**—I sympathise entirely with the remarks of the noble and learned lord, but I cannot help remembering that he was a member of the Government which passed the Act that he has denounced with so much vigour. (Laughter.) When I sat exactly where he is sitting now I pleaded in vain for a greater extension of the number of years, and I prophesied the results which have actually occurred. I rather think the noble and learned lord opposite is imitating those secretaries of the Middle Ages who went about laying stripes on their own shoulders for the sins they had committed. The noble and learned lord has held up to our admiration the example of the South Sea Islands in this matter; however, I am too delighted to see that the noble and learned lord recognises the difficulty in which we find ourselves to be critical as to the precise means by which his conversion was brought about. It is matter of regret that we have not been able to make greater use of this invention, considering the vast amount of capital we have at our disposal and the great need in our smoky towns of diminishing the unconsumed carbon in our atmosphere. Although the Board of Trade has, acting under the guidance of the distinguished statesmen who presided over it during the term of office of the noble and learned lord, to some extent, I am afraid, since that time, exaggerated the danger of liberty in this matter, it is fair we should remember that we have had very severe lessons in respect of leaving uncontrolled powers to municipalities and public authorities to make binding bargains with trading companies. On the subjects of water and gas we have had very severe lessons, and we are now struggling under the difficulties that have arisen. The noble viscount near me (Viscount Cross) was said some years ago to have wrecked the Goverment by the proposals he made for the purchase of the undertakings of the London water companies. We now only wish that the proposals which were then denounced could be revived with success and carried into effect. We have bound ourselves by promises to the water companies which give them a hold upon us that I do not know we shall ever shake off. Undoubtedly the price at which this essential article may be furnished must have very considerably affected the progress of sanitary measures so much required in many parts of the metropolis. We have contiived to make some agreement with the gas companies. Twenty years ago we woke up to the fact that we had allowed most improvident agreements to be made with them, that we had allowed them, on the faith of competition which did not exist, to charge enormous prices. At the present moment in regard to gas companies, we are under difficulties which could not have been foreseen by our forefathers when these terms were made, or I am convinced that the measures which they allowed to pass would have been seriously modified. The truth is that in both these cases we have made exceedingly bad bargains, and we are bound by them; and, therefore, it is not wholly unreasonable that in dealing with this new element we should approach it with some amount of caution. I quite believe we may have been too cautious, and may have run into an opposite extreme, and, by hindering the production of the electric light at the cheapest prices, may have prevented the development of this new industry. If the noble and learned lord can show us that the terms we ask can be reasonably modified, no feeling of self-love will prevent us from making any alteration which your lordships may think desirable. I think we ought not to be misled by the desire to give the municipalities control over these matters. We have a sufficient number of examples as to the capacity of municipalities to carry on the business of traders on a large scale. We know the temptations are enormous, and the danger we have to face is not that the municipalities themselves will administer these trading concerns, but that they will be in the hands of paid officers wielding an enormous and irresistible power, exposed to temptations to which the municipalities themselves will not be liable, and at the same time not having the responsibility which rests upon the municipalities. I feel that the whole question of the expediency of giving this power to the municipalities has of late years been too much assumed without sufficient proof, and we should be cautious about surrendering ourselves wholly to them and preventing that protective competition of private companies which is so desirable in the interests of the community at large.

The **Earl of Kimberley** said he remembered perfectly well that the noble marquis objected to the Bill of 1882 as being too stringent; but the latter part of the speech of the noble marquis answered the preceding part—namely, that the Government and the House in 1882 had before them evidence of the previous mistakes that had been made with regard to gas and water legislation. The Board of Trade, which was then presided over by Mr. Chamberlain, was extremely anxious that in the matter of this new invention they should not fall into their former errors. In the discussion on the Bill in 1882 he admitted that it was an experiment, and that they might possibly, by future legislation, be compelled to amend the Bill if they found that they had erred on the side of severity. It was much safer to err on that side than on the side of indulgence. With regard to the municipalities, they undoubtedly ran the risk of having too much officialism; but he would point out that there was likely to be a most severe pressure put upon the ratepayers in the carrying out of improvements, and it was a matter worthy, in his opinion, of very careful consideration, whether by giving the municipalities the power to work this large invention, which provided what was, in fact, one of the necessaries of life, they should not be affording them a means of relieving themselves to a considerable extent of the burdens under which they laboured. It was because they wished to see this end accomplished that they desired to have the terms in this matter of electric lighting less stringent.

The Bill was read a second time.

LEGAL INTELLIGENCE.

THE FAURE ELECTRIC ACCUMULATOR COMPANY (LIMITED) v. PHILIPPART.

This case (says the *Times*) had arisen out of the affairs of the Faure Electric Company, and it raised many important questions of joint-stock company law. The company was formed in 1882 for the purpose of carrying out an agreement between M. Faure and "La Force et la Lumière," a *société anonyme* formed in Belgium, and represented by M. Philippart and others, to carry out electric lighting in that country. The Faure Company were to acquire the patented invention of M. Faure from him and the Belgian Company—which had become in part possessed of it—and then to work it with new capital. M. Philippart held 22,000 shares, and he and others 2,000 more, on which calls were made, and then, in January, 1883, there was an arrangement which, it was said, on behalf of the Company, was a forfeiture of his shares, reserving the Company's right to calls then owing, which, as they contended, meant calls made, whereas he insisted that it meant calls payable before the forfeiture. In July, 1884, the Company went into liquidation, and on the 30th of April, 1887, the liquidator, in the name of the Company, brought this action to recover the calls. These calls amounted with interest to £70,459, and the action was to recover that amount. The calls claimed were:—The first call of £1 per share on 22,537 shares, made in November, 1882, and payable on December 6, and interest at 10 per cent. (according to the articles of association), down to date of action, amounting altogether to £9,907; a second call of £1 per share, made December 19, 1882, and payable in January, 1883, with the interest to date of action, amounting to £9,753; to first call of £1 per share on 2,000 ordinary shares of £10, standing in the joint names of the defentant and two other persons, and forfeited, as contended by the Company, on the 3rd of January, 1883, £2,000; interest thereon up to April, 1887, £879; to second call on the 2,000 shares, December 19, 1882, £2,000; to interest thereon, £854 14s.—total, £70,459 14s. The defence set up was a denial that at the time of forfeiture any calls were owing, and in the alternative that if the defendant held the shares, as alleged, he held them as trustee for the Belgian Company, incorporated in Belgium and called "La Force et la Lumière;" that it was agreed between the English company, the Belgian company, and the defendant that the shares should be forfeited only upon the terms that neither the defendant nor the Belgian company should be liable for any calls upon the shares, and that accordingly, at a Board meeting of the directors of the English company on the 26th of June, 1883, a resolution was passed that it was not intended at the time of the forfeiture that the liability for past calls should continue to attach, as the forfeiture was for the common profit of the shareholders, and that the sum of £2 per share posted in the books of the company as due on the shares be transferred from capital account to the credit of the shareholders concerned—that is, Messrs. Philippart; and that, in short, an arrangement was made to the effect that neither the Belgian company nor the Messrs. Philippart should be liable for these calls. And it was alleged that the terms of arrangement were contained in an agreement of January 7, 1883, between the French Electrical Power Storage Company, the English company (now plaintiffs), and the Société la Force et la Lumière and the defendant. The action was by the liquidator of the company.

Mr. Channell, Q.C., and Mr. Grosvenor Woods were for the plaintiff company; Mr. Finlay, Q.C., Mr. J. Henderson, and Mr. Merrick were for the defendant.

The great point in the case was whether shares can be forfeited for non-payment of calls before the calls are payable by the terms of the resolution making the calls. The company relied on a decision of Lord Romilly (Master of the Rolls) that a call is made from the day on which it is made, although it is payable on a future day ("*In re* the China Steamship Company," 38 *L. J.*, Chancery, 512). Formal proof was given on the part of the plaintiff company that the calls were duly made; but then it appeared from the dates as to one of them that the call, though made before the forfeiture, was payable afterwards. As regarded the interest—10 per cent.—it was contended on the part of the company that upon forfeiture the interest should be "reserved," but on the part of the defendant it was contended that this only applied to the interest due at the time of the forfeiture, and that no interest due under the articles could accrue afterwards (Stocken's case, "Law Reports" 3, Chan. Appeals 41), so that a claim for continuing interest at 10 per cent. after the forfeiture, to the amount of nearly £20,000, was wholly untenable. Then there was a point as to one of the calls with respect to the quorum, it being contended that there was no quorum at the meeting of directors which made the calls, there being only two directors present, whereas by the articles there ought, it was said, to be three (Buckley's "Joint Stock Companies Law," 189). As to this, under article 69, "the Board of Directors shall consist of not less than three directors. It shall, nevertheless, be lawful to increase or, on the occurrence of vacancies, to diminish the number of directors by resolution of a general meeting on the recommendation of the Board." Rule 78:—"The directors may meet together for the despatch of business, adjourn and regulate their meetings and otherwise as they think fit, and determine the quorum necessary to form a Board for the transaction of business; and until otherwise determined three shall be a quorum." On April 26, 1882, there was a resolution that two should form a quorum, and upon these rules and the resolution the question as to the validity of one of the calls depended. Upon this point the Company relied on the case of the "Scottish Petroleum Company" (23, Chancery Division; "Buckley," p. 422), which held that where the articles contain one similar to the above, and there has been a Board of the minimum number, but by casual vacancies it has fallen below the minimum, a quorum of the continuing directors may act, though it would be otherwise if the continuing directors were less than a quorum. But on the part of the defendant it was denied that this case was applicable, as it related to the allotment of shares. On the main question as to the alleged arrangement it was contended on the part of the Company that this could not be done, as it would be in effect a purchase back by the company of their own shares, and giving up a part of their called-up capital ("Trevor v. White," 12, Appeal Cases). The other points were also controverted, and the case was argued at length on these questions by Mr. Channell and Mr. Finlay, after which the learned Judge took time to consider his judgment, which, on the 27th inst., was given as follows:—

Mr. Justice Hawkins: The plaintiff company was duly incorporated on Feb. 15th, 1882. Its nominal capital was £1,000,000, divided into 80,000 ordinary shares of £10 each, and 200,000 deferred shares of £1 each. The defendant at the time of making the calls hereafter mentioned was the holder of 22,532 ordinary shares standing in his own name, and of 2,000 like shares standing in his own name with two others, making a total of 24,532 ordinary shares, upon each of which £2 had been paid. On November 7th, 1882, a call of £1 per share was made, payable on December 6th. On December 19th a further call of £1 per share was made, payable on January 20th, 1883. To recover these calls, with interest at the rate of 10 per cent. from the dates upon which they were payable up to the present time (under Article 24), this action was brought. On January 3, 1883, by resolution of the board of directors, constituted as hereafter mentioned, the whole of these shares were declared forfeited for the non-payment of the first call (under Article 39). The defendant himself was a member of this board, presided at it, and assisted to pass the resolution. No objection was raised as to the validity of the first call. Indeed, having regard to the resolution, no such objection could be raised. The second call, however, was objected to by the defendant on the grounds, first, that it was not legally made, and, secondly, that if it were it was not "owing" within the meaning of Article 39 at the time of the forfeiture. The first of these objections was based upon three grounds. By Article 69 "the board of directors shall consist of not less than three nor more than seven." By Article 78 the directors have power to determine the quorum necessary to form a board meeting for the transaction of business, and "until otherwise determined three shall be a quorum." By a resolution of the directors passed on April 26, 1882, the number of a quorum was reduced to two. Before December 19, 1882 (when the second call was made), by the resignation of some of the directors originally appointed the board was reduced to two, the defendant being one and a Mr. Cadiot the other. These two were sufficient to form a quorum, but were not sufficient to form a board for the purposes of transacting the business of the company upon December 19. At that meeting the defendant was voted to the chair; they then, as the first act of business, proposed a resolution that the board should increase itself to five members, and they proceeded to nominate three other gentlemen as directors, who immediately accepted the office, and thus the board was increased to five, and at once proceeded to pass the resolution for the second call. It was urged for the defendant that until the board was increased to three members at least the two gentlemen, though sufficient to form a quorum of a properly constituted board, had no power to act, either by increasing the number of directors or making a call. As between the company and the general body of the shareholders, who were no party to the resolution, I think these objections would be fatal. By Article 22 calls are to be made by "the Board of Directors," and if there be no valid board it is difficult to see how there can be a quorum of the board. The word quorum in its ordinary sense has reference to the existence of a completed body of persons, of whom a certain specified number are competent to transact the business of the whole. But a quorum of a board of directors does not constitute the board, though in the absence of other existing directors it may legally transact all such business as the whole board is competent to transact. Nothing could illustrate this proposition better than the articles of the plaintiff company, which require a minimum of three directors to form a board, though two may constitute a quorum of the board when formed. The case of the Scottish Petroleum Company (23 Ch. Div., 412) does not militate against this view, for although in that case it was held that a quorum of two directors of a board which was not filled up to its minimum number might make an allotment of shares, it was held so, not because the quorum was equal to a duly constituted board, but because of a provision in the company's articles to the effect that in the event of a casual vacancy occurring in the board of directors, the continuing directors might act, notwithstanding such vacancy. In the articles of the plaintiff company I find no such special provision, and thus the two cases are distinguishable. It was said, however, on behalf of the plaintiff company that in their case, before the call was made the board was made up to more than its minimum number by the appointment of the three additional directors. This brings me to the question as to whether the two directors who alone represented the plaintiff company at the commencement of the board meeting at which that increase took place were competent to add to their number, and fill up the vacancies so as to constitute a valid board. I am of opinion that they were not. By Article 73, it is provided that "Any casual vacancy occurring in the office of director before the ordinary general meeting in 1885 may be filled up by the board of directors appointing some qualified member thereto." Admitting that the vacancies were "casual vacancies," I fail to understand how a "casual vacancy," which can only be filled up by the board, can be filled up if no properly constituted board is in existence at the time. It may, I know, be argued that this difficulty is surmounted by the latter part of Article 78, which provides that "the directors assembled at a board meeting duly summoned may, if a quorum is formed, exercise all the powers of a board of directors, notwithstanding any vacancy in the number of directors." The very words of this article imply, his Lordship continued, that there must be at the time an existing board to be summoned, though there may be a vacancy in its full number, as ordi-

narily composed. It seems to me that the true meaning of that article is, that if the numbers of the existing legally constituted board are duly summoned, but a quorum only attends, the quorum may exercise the powers of a board. This, however, is far from saying that two directors may constitute a board, which the articles require to be composed of three at least. I am aware that dicta are to be found in the case of "The York Tramway Company v. Willows" (8 Q.B.D., 685), which may be cited as militating apparently against this view. It is to be observed, however, that those dicta had reference to articles differing from the present ones, and, moreover, they were not essential to the decision of that case. It was urged that the business would come to a standstill unless the two continuing directors were able to appoint another to make a valid board for the transaction of the business. It may be that the business would be at a standstill until a complete board was formed; but that argument of inconvenience is not sufficient to confer upon two directors only the powers of a Board which the very constitution of the company says shall not consist of less than three. I cannot regard the objections I have discussed as other than serious and substantial ones. The subscribers to the company have, by the articles of association, a right to have the benefit of the judgment of, and to have their affairs transacted by, a board of three directors at least, and I can conceive for matters of business nothing more important than the selection and appointment of the directors to whom the affairs and management of the company are to be intrusted, and whose integrity and action may make all the difference between success and insolvency. When, therefore, a company's articles provide for the filling up of a vacancy by the board, I think it means a properly-constituted board, and not merely two directors, as here, who do not and cannot form a board. This question was, his Lordship said, fully dealt with in "*In re* Album Spinning Company—Bottomley's case" (16 "L.R." Ch. D., 681). Continuing, he said,—There is, however, a ground upon which, I think, the liability of the defendant may be sustained, notwithstanding the objections I have mentioned and discussed. The defendant, as a director, was in the chair and assisted to pass the resolution to fill up the vacancies in the board. He, with his other colleagues, passed the resolution for the call under discussion, and also for another call payable on February 19, directed notices of forfeiture to be issued to members who had not paid the first call, and passed a resolution for an interim dividend; and at the next meeting on January 3, 1883, the minutes of the previous meeting were read over and signed by the defendant as chairman. At the meeting of January 3, the defendant being in the chair, resolutions were passed forfeiting shares for the non-payment of the first call, including those held by the defendant himself in respect of which the calls were made. Having regard to these facts, I think the defendant is estopped from disputing the validity of the call in question. I do not think it necessary upon this point to do more than refer to the judgment of the present Master of the Rolls in "The York Tramways Company v. Willows" (*ubi sup.*, page 699). The next question raised by the defendant was whether the second call, which was made before (but the day for payment of which had not arrived when) the resolution of forfeiture was passed, could be said to be owing at the time of such forfeiture. Article 39 provides that "any member whose shares have been declared forfeited shall notwithstanding be liable to pay to the Company all calls owing upon such shares at the time of the forfeiture, and the interest (if any) thereon." The defendant contended that, inasmuch as the second call, made on December 19, 1882, was not payable until January 20, 1883, it could not be said to be owing when the shares were declared forfeited on January 3, 1883. Independently of authority, I should have been of opinion that immediately after the call was made it was owing, according to the true construction of the article, though payment of it could not be legally enforced till a month afterwards. The judgment of Lord Romilly in "The China Steamship, &c., Coal Company, Dawes's case" (38 *L. J.*, Ch., 512), however, is in point in support of this view. As regarded the claim for interest, it was contended for the defendant that the 24th article, which makes a member liable to pay interest upon his unpaid calls, from the day appointed for their payment to the time of actual payment, at 10 per cent. per annum, was no longer obligatory, upon the defendant's ceasing to be a member, by the forfeiture of all his shares; and that after such forfeiture no interest could be clamed—and certainly none could accrue after the forfeiture; and, further, that even if any interest could be recovered in respect of calls remaining unpaid after the forfeiture, it could not be at the rate of 10 per cent., but only under (3 and 4 Will. IV., cap. 42, sec. 28; in support of which, "*In re* Blakeley Ordnance Company, Stocken's case" (5 "L. R.," Eq., 6, and 3 "L. R.," Ch. App., 412), was, his lordship said, cited. Having referred to the judgment in that case, his Lordship continued:—It is unnecessary to inquire at length into the considerations upon which it was decided, which are fully given in the judgments of Lords Cairns and Romilly. But for the words in the 39th article of the plaintiff company, "and the interest (if any) thereon," this case (Stocken's) would have been conclusive in favour of the defendant's contention. Those words, however, in my opinion, create a right in the plaintiff Company to interest at the rate of the 10 per cent. named in Article 24 up to the time of the forfeiture upon the first call, which had previously become payable, but not upon the second call, the time for payment of which had not then arrived. I think that the true construction of the 39th article was to reserve to the plaintiff Company all such rights as they might have against a defaulting shareholder up to the date of the forfeiture of his shares, and to confer upon them the power to enforce such rights by an action, notwithstanding the extinction by Article 40 of all rights incident to the forfeited shares. As regarded the interest claimed to have accrued after the forfeiture, his Lordship said he was clear, on the authority of Stocken's case (*ubi sup.*), that none could be claimed either under Article 24 or under the statute, because no demand of payment was ever made after the forfeiture, when the new right so sought to be enforced had arisen. The result was that interest could only be allowed upon the first call at the rate of 10 per cent. up to January 3, 1883, when the shares were forfeited and that all other interest would be disallowed. As regarded the defence set up that it was agreed between the plaintiffs and the defendant and the Belgian Company that the shares should be forfeited only upon the terms that the liability of the defendant to pay calls in arrear should cease, his Lordship held that there was no evidence to support any such agreement. He further said that, even had such an agreement been proved, in his opinion it would have been invalid, because the board had no power to enter into any such agreement. As to the defence that, assuming the defendant had been liable to the plaintiff Company, as alleged, his liability had been discharged by bankruptcy proceedings in France, the learned Judge held that this was not proved in evidence, and that even if it had been it would have afforded no defence (*vide* "Bartley v. Hodges," 1 "B. and S.," 375). In conclusion the learned Judge said:—In my opinion, the defendant has established no legal answer to the plaintiff's claim for the unpaid calls, but has to a large portion of the claim for interest. My judgment, therefore, is for the plaintiff company for the full amount of those calls, amounting in the whole to the sum of £49,064, together with interest upon £24,532, the amount of the first call, at 10 per cent. per annum from December 6, 1882, when that call became payable, up to January 3, 1883, the date of the forfeiture, amounting to £204—say £204—making a total of £49,268.

COMPANIES' MEETINGS.

THE ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION.

The seventh ordinary general meeting of the Anglo-American Brush Electric Light Corporation (Limited) was held on Friday last at the City Terminus Hotel.

Lord Thurlow, F.R.S., presided, and, in moving the adoption of the report, said they had now worked at a profit during the whole of 1886 and 1887. The volume of their business in the past year had increased, compared with that of 1886, by 23 per cent., and by the economies they had been enabled to introduce during the same time their net profits had increased by nearly 10 per cent. That, he thought, was a very favourable statement of affairs taken by itself, but it was still more satisfactory when it was considered by the side of the great fall that had taken place in the prices of all electrical appliances. In illustration of the great fall of prices, which had considerably increased the difficulties of the Company, he might mention that in 1881 the largest class of Brush dynamo made by them cost £800; whereas they were now making a machine more efficient, more powerful, and superior in every way for £360. With the aid of their very efficient staff, they had been enabled to counterbalance that depreciation. Besides the economies effected by the business being now all under one roof, by their having made advantageous contracts for coal, oil, and other supplies, and by the reclassification of rates for the conveyance of electrical machinery to which the railway companies had agreed. They had acquired their Austrian business through having absorbed on favourable terms the undertaking of the International Electric Company. The assets taken over consisted, broadly speaking, of two things—the street lighting installation at Temesvar, in Hungary, and the large share held by the International Company in the firm of Kremenezky, Mayer, and Co., electrical engineers and manufacturers, in Vienna. Temesvar consisted really of three towns joined together, and the district was entirely lighted by electricity, and had been so lighted for some years. The mains were over 30 miles in length. The lighting, which was effected by 700 incandescent lamps, was exclusively by the Brush system. The contract was for 25 years, at the expiration of which the municipality could either renew the contract or purchase the installation at a very fair valuation. The lighting was now being done at a small profit, and the private lighting along the 30 miles of streets was almost daily increasing. Since absorbing the undertaking of the International Company they had acquired the remaining portion of the business of Kremenezky, Mayer and Company. Since the publication of the report, the accounts of the firm for the past year had come to hand, and they showed a profit. They had been generally commended for the way in which they had carried out the contract for lighting the Jubilee Exhibition at Manchester last year. That was the largest piece of arc lighting ever done in England, 600 lamps being used. They had now undertaken a similar piece of work for the Glasgow Exhibition, for which, however, 400 lamps would be required. After what had occurred in the past year they considered that they had established their position in Great Britain. In regard to the patent for compound winding of dynamos, no machine could be made in future on that principle without the Company receiving a royalty. Only one firm had contested their rights; but if the case came into Court they had no doubt about being able to establish their claim. They were now making an alternate current machine under an entirely new design. They had also patented and were adopting a new type of transformer, for transforming high tension into low tension current, and *vice versa*. He hoped the shareholders would approve—as they would do by adopting the report—the bonus scheme for admitting the principal officers and the heads of departments to a participation in the profits made by the Company. The patents now stood in the balance-sheet at £57,674, and knowing what those figures covered he considered the item an eminently satisfactory one. They owed tradespeople at the end of the year £12,341, or £500 less than their indebtedness a year previously; while the amount owing to the Company on the 31st December was £45,600, or 50 per cent. more than was due to them a year ago. The negotiations with the Commissioners of

Sewers had been pending for several years. The contract would only give them a fair tradesman's profit, but indirectly it would benefit the Company immensely. He believed they would be able to bring the authorities of the South-Eastern Railway Company to a sense of the justice of the demands made by the Corporation for reasonable compensation for any inconvenience which the railway company might put them to in connection with the acquisition of their premises at Belvedere-road. In regard to the litigation with the Edison and Swan Company, they were convinced that they had a good case, and that view was supported by their legal and technical advisers. He strongly urged every one who was interested in electric lighting to read the chapter on the early history of the gas industry in Mr. Burdett's "Official Intelligence" for 1888, in which reference was made to the enormous amount of capital sunk at the outset in that industry, and to the fact that it took 25 years before gas could be worked at a profit. Not a quarter of the money that was lost, sunk, or thrown away in the early history of the gas industry had been lost, sunk, or thrown away in introducing the electric light; and as to its taking twenty-five years to make the electric light pay, he did not like to prophesy, but he would venture to say that twelve years from the introduction of the science in 1880 there would not be a gas lamp in the streets of any town in England. The Bill introduced by him into the House of Lords last year, which could not then, owing to various difficulties, be proceeded with in the House of Commons, had been re-introduced into the House of Lords this year. He had received the assurance of the support of the Government, and he thought there was every reasonable prospect of the Bill becoming law.

Mr. J. Scudamore Sellon seconded the motion.

In reply to a question, the **Chairman** stated that the reason he laid so much stress on the street lighting was because he felt that by that means they would be enabled to get the electric light into private houses.

The report was unanimously adopted, and the retiring directors and auditors were re-elected.

TELEPHONE COMPANY OF EGYPT.

The annual general meeting of the Telephone Company of Egypt (Limited) was held on Tuesday at the offices, Austinfriars, General Alexander Fraser, C.B., presiding.

The **Chairman** said he thought the shareholders might regard the present position of the company as satisfactory. For the past year they had again proposed to pay 6 per cent.; and after writing off a considerable sum for depreciation they would carry forward an amount equal to about 1 per cent. more on the preference capital. Their gross business had increased by quite 50 per cent. since they started, but the working expenses had not grown by anything like the same proportion. For their economical working they were greatly indebted to their late manager, Mr. A. D. Evans, whose death they very much regretted, and whose son, Mr. W. N. Evans, they had elected to the position. Since the issue of their report the extension of their business to Hélouan, about 16 miles from Cairo, had been completed, and they expected a large business from that connexion. After consulting the principal shareholders, the board had decided to ask the present meeting to pass a resolution extending the borrowing powers of the Company from £5,000 to £20,000. They suggested that there should be a present issue of £10,000 only, of which a portion would be required to pay off a loan, and the remainder would represent working capital. Including that loan, they had spent about £10,000 in new constructions over and above the capital issued for acquiring the business as a going concern. He thought they would have no difficulty in placing their debentures at 6 per cent. He concluded by moving the adoption of the report and the payment of a dividend of 6 per cent. on the preferred shares.

Mr. Henry Grewing seconded the motion, which was unanimously adopted.

A resolution was afterwards passed authorizing the directors to issue debentures to an amount not exceeding £20,000.

PROVISIONAL PATENTS, 1888.

FEBRUARY 24.

2772. **Improvements in electrical safety appliances.** Killingworth William Hedges, 8, Quality-court, London, W.C.

2784. **A method of and apparatus for electrically lighting railway and other carriages.** John Imray, 28, Southampton-buildings, Chancery-lane, W.C. (Robert Imray, South Australia.)

2785. **Improvements in holders for electric glow lamps.** Edward Frederick Hermann Heinrich Lauckert, 28, Southampton-buildings, Chancery-lane, London, W.C.

2794. **Improvements in electrical firing keys or contact makers.** Charles Ambrose McEvoy, The London Ordnance Works, Bear-lane, Southwark, Surrey.

FEBRUARY 25.

2808. **Electro-magnetic conductors for electric and magnetic machines, induction coils, transformers, &c.** Henry Francis Joel, 44, Lavender-grove, Dalston, London.

2819. **Improvements in electrical measuring instruments.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Henry John Payne, 132, Horseferry-road, Westminster S.W.

FEBRUARY 27.

2876. **Improvements in the method and means of working the driving appliances on electrically propelled vehicles.** Michael Radcliffe Ward, 55, Chancery-lane, London, W.C.

2883. **Lighting a lamp from the incandescent wire of a galvanic battery.** Henry Ferdinand Richardson, Oaklands, Waldegrave-road, Teddington.

2933. **Improvements in mechanism for regulating the force of dynamos or magneto-electric generators.** Herbert John Haddan, 18, Buckingham-street, London. (Warren Samuel Hill, United States.

FEBRUARY 28.

2956. **Automatic electrical "fog-signalling" on railways working in conjunction with the present block system.** Arthur Butler Harris, Trinity College, Oxford.

2958. **The production of musical tones directly by electricity, and the application thereof.** John Eshelby and Edwin Eshelby, 5, Eden Quay, Dublin.

FEBRUARY 29.

3041. **An apparatus for attaching to automatic delivering machines, for regulating and governing any required time for lighting or igniting cigars and cigarettes by electricity.** Edward Elijah Atkins, 9, Villa-grove, Handsworth, near Birmingham.

3072. **Improvements in automatic electric induction apparatus.** Henry William Rhoads and Frederick William Ticehurst, 8, Quality-court, London.

3075. **An improved clutch for regulating feeding rods in electric arc lamps.** Alfred William Southey, 1, Cullum-street, City.

3097. **An improvement in holding the plates of secondary voltaic batteries.** Bernard Mervyn Drake and John Marshall Gorham, 28, Southampton-buildings, Chancery-lane, London, W.C. (Complete specification.)

MARCH 1.

3146. **The manufacture of a new non-magnetic alloy.** Heinrich Ostermann and Charles Lacroix, 68, Fleet-street, London.

3149. **Improvements in galvanic batteries.** Louis Kayser, 23, Southampton-buildings, Middlesex.

COMPLETE SPECIFICATIONS ACCEPTED.

MARCH 21, 1887.

4225. **Improvements in electricity meters, parts of which improvements are applicable to dynamo-electric generators and motors.** George Hookham, 7, Staple Inn, Middlesex.

APRIL 16, 1887.

5662. **A system of generating, reproducing, and distributing electricity.** William Maxwell, 34, Claybrook-road, Fulham, S.W.

APRIL 19, 1887.

5709. **Improvements in dynamo-electric machines.** Alphonse Isidore Gravier, 6, Bream's-buildings, London, E.C.

APRIL 22, 1887.

5867. **Improvements in secondary batteries.** William Kingsland, 49, Cambridge-road, Gunnersbury, W.

APRIL 27, 1887.

6168. **Improvements in or connected with telephones for checking payment for the use of the telephones.** Hubert Fielden Jackson, 47, Lincoln Inn-fields, London, W.C.

APRIL 29, 1887.

6294. **Improvements in the electrolytic treatment of zinc and its ores.** Alexander Watt, 6, Bream's-buildings, E.C.

DECEMBER 23, 1887.

17,704. **An improvement in telephones.** Abram Charles Herts, 33, Southampton-buildings, Holborn, London.

SPECIFICATIONS PUBLISHED.

1887.

3046. **Registering, &c., earthquakes, &c.** T. Gray. (Milne.) 11d.

3658. **Alternating current transformers.** R. Dick and R. Kennedy. 8d.

4781. **Electric batteries.** The Electrical Power Storage Co. and W. H. Butler. 6d.

4809. **Insulating electrical conductors.** E. Tortora. 8d.

17,837. **Generating electricity from heat.** P. M. Justice. (Acheson.) 8d.

17,888. **Electro-magnetic marine governors.** G. A. Smith. 6d.

NOTICE.

The Notices hitherto sent by the Office to Applicants for Patents, reminding them of the date for filing a Complete Specification, will not in future be issued.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	98 to 100
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
15 Feb.	10/0	Anglo-American	100	40
15 Feb.	20/0	— Pref.	100	66¼
12 Feb., 85...	5/0	— Def.........................	100	15
29 Dec.........	3/0	Brazilian Submarine.........	10	11 15-16
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
15 Feb.	8/0	Cuba	10	12¾x
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	3¼
18 Oct.	5/0	— 10% Pref.	10	9½
14 Oct.	2/0	Direct United States	20	9⅛
12 Jan.	2/6	Eastern	10	11½
12 Jan.	3/0	— 6% Pref.	10	14½
1 Feb.	5%	— 5%, 1899	100	109
28 Oct.	4%	— 4% Deb. Stock	100	106
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	105
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	104½
12 Jan.	5/9	German Union	10	9¼
27 Jan.	1/6	Globe Telegraph Trust......	10	5¾
27 Jan.	3/0	— 6% Pref.	10	13⅝
3 Jan.	5/0	Great Northern..............	10	14¼

Dividend.		Name.	Paid.	Price. Wednesday
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105x
28 July	10/0	India Rubber, G. P. & Tel.	10	16⅜x
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
16 March ...	5%	Maxim Weston	1	3-16
15 May	5%	Oriental Telephone	11	½
14 Oct.	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2½
15 Feb.	15½%	Submarine	100	145x
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	38¾x
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	13⅝
......	...	West African..................	10	5
1 March ...	5%	— 5% Debs.	100	93
29 Dec.........	6/0	West Coast of America ...	10	5¾
31 Dec.	8%	— 8% Debs.	100	116
14 Oct.	3/9	Western and Brazilian......	15	9½
14 Oct.	3/9	— Preferred	5½	6½
......	...	— Deferred..................	2½	3¼
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	105
......	...	West India and Panama ...	10	⅞
30 Nov.	...	— 6% 1st Pref.	10	10
13 May, '80...	...	— 6% 2nd Pref.	10	6¼
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Sept.	6%	— 6% Sterling	100	101x

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. March 2 ...	£4,435	...
Cuba Submarine	M. of Jan. ...	3,300	+ £82
Direct Spanish......................	M. of Feb. ...	1,858	+ 235
— United States	None	Published.	...
Eastern...............................	M. of Jan. ...	56,164	+ 2,729
Eastern Extension	M. of Jan. ...	£39,878	+ £547
Great Northern	M. of Feb. ...	41,800	+ 2,200
Submarine	None	Published.	
West Coast of America	M. of Feb. ...	4,625	...
Western and Brazilian	W. March 2 ...	3,766	...
West India and Panama	F. Feb. 29......	3,139	+ 299

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ending March 2 amounted to £4,435.

Armstrong's Electric Light Company.—Captain C. D. Inglis, R.N., resigned his seat on the board of the Armstrong's Electric Light and Power Company, Limited, on February 28.

West Coast of America Telegraph Company.—The traffic receipts of the West Coast of America Telegraph Company (Limited) for the month of February were £4,625.

Great Northern Telegraph Company. — The receipts of the Great Northern Telegraph Company for February, 1888, amounted to £20,400, and from January 1 to February 29, to £41,800 against £39,600 for the corresponding two months in 1887.

New Company.—The Electrical Works Construction and Maintenance (Limited): Resistered by George Annestey Grindle, 19, Great Winchester-street, with a capital of £2,000, in £1 shares. Object, to carry on the business of electricians and electrical engineers.

Western and Brazilian Company.—The traffic receipts of the Western and Brazilian Telegraph Company (Limited) for the week ending March 2, after deducting the fifth of the gross receipts payable to the London Platino Brazilian Telegraph Company, were £3,766.

German Union Telegraph Company.—The directors of the German Union Telegraph Company have declared a final dividend of 8s. 3d. per share free of income-tax for the year 1887, making the total distribution 14s. per share, or at the rate of 7 per cent. per annum.

Direct Spanish Telegraph Company.—The estimated traffic receipts of the Direct Spanish Telegraph Company, Limited, for the month of February amounted to £1,858, against £1,623 for the corresponding period of last year.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company (Limited) for the half-month ended Feb. 29 were £3,139, as compared with £2,840 in the corresponding period of 1887. The November receipts, estimated at £5,236, realised £5,314.

Electrical Companies Registered in February:—

House-to-House Electric Light Supply, in £5 shares	£350,000
Macmahon's Electric Automatic Registering Co., in £1 shares	20,000
Notting Hill Electric Lighting, in £1 shares......................	100,000
Bournemouth Electric Light and Power, in £5 shares	4,000
Gulcher (New) Electric Light and Power Co., in £1 shares...	70,000
Electrical Automatic Delivery Box, in £1 shares	60,000
Institute of Medical Electricity, in £1 shares	20,000
Eclipse Electric Lighting Syndicate, in £1 shares...............	20,000
Electric Traction, in £10 shares	30,000
Series Electrical Traction Syndicate, in £1 shares...............	30,000
Showing a total capital required of	£704,000

German Union Company.—The report of the directors of the German Union Telegraph and Trust Company (Limited) for the 12 months ending December 31, 1887, states that the total receipts during the 12 months amount to £15,368, which, with a balance of £31 brought forward from last account, make a total of £15,399. The expenses for the same period amount to £892; of this sum £750 is provided by the German Union Company of Berlin. Out of the receipts an interim dividend of 5s. 9d. per share was distributed on January 17 last, and the directors recommend the payment of a further dividend of 8s 3d. per share, making a total distribution for the year of 14s. per share, free of income-tax, or at the rate of £7 per cent. per annum (as against £6 paid last year), leaving a balance of £156. 3s. 5d. to be carried over to next account. The proposal of the Imperial German Government for the acquisition of the cables and property of the Berlin Company has been accepted, and an agreement on the terms sanctioned by the extraordinary general meeting of this Company of November 28, 1887, has been entered into, subject to the formal approval of the Reichstag, which is daily expected. The result of the agreement will be, so far as can at present be foreseen, that the Berlin Company will begin to go into liquidation in April next, and that the shareholders of this Company will receive a return in respect of their capital early in 1889, when the Government will pay the purchase-money. The exact sum to be paid to the shareholders of this Company cannot be determined at present, but it will probably be about par, that is about £10 per share, less expenses of liquidation, which will make a fractional reduction.

New Thermo-electric Couple.—Any progress bearing upon the question of the direct conversion of heat energy into electrical work is of interest to a considerable section of our readers. We therefore—although the details of the discovery are not yet forthcoming—notice the statement made by some of our foreign contemporaries that a new thermo-electric couple having an E.M.F. as high as 0·18 volt, and a resistance as low as 0·009 ohm, has been constructed by M. Heimel. The importance of these figures becomes evident when it is pointed out that the thermo-electric couple best known in this country, that of Clamond, has an E.M.F. of only 0·02 volt with a resistance of 0·02 ohm.

Barcelona Exhibition.—At the request of the Secretary of State for Foreign Affairs, the Society of Arts has undertaken to promote the interests of the Exhibition in this country, and to act as the intermediary between British exhibitors and the Executive of the Exhibition. The Exhibition is announced to be opened on the 9th April, and the date for the receipt of applications from foreign exhibitors has already passed. A request for an extension of the time has been made to the Spanish Executive. In the meantime, British manufacturers who wish to take part in the Exhibition, and have not already sent in applications for space, may apply to the secretary of the Society of Arts, John-street, Adelphi, W.C.

Electric Lighting at Glossop.—Mr. Herbert Rhodes, in reply to a statement made at the last meeting of the Council, during the discussion on the purchase of the gas-works, with reference to the adoption of the electric light at some of the local mills, said the firm he represented put 1,400 electric lamps into their mills in 1886; and these gave so much satisfaction that in 1887 they put in another 1,000. Two other local manufacturers had adopted the electric light; and though corporations ought to own gas and water works, he considered that under these circumstances it would be the height of folly to entertain the idea of purchasing the gas-works. The Mayor (Alderman Sidebottom) said he quite agreed with these remarks.

Taunton.—The Lighting Committee of the Town Council have resolved to recommend the Council to provide 30 additional arc lamps for public lighting of the streets of Taunton, and they have suggested where these lamps should be placed. The limits are Haines-hill on one side, the Laurels, Staplegrove; the corner of Wellington-road, the bottom of East-reach, the end of Silver-street and Mountlands, and the corner of the roadway near the Railway Station. It is proposed to place a lamp opposite St. George's Church, one at the junction of the roads near the Compass Inn, one in Castle Green, one near the Convent, and one at the junction of the Staplegrove-road and Nursery Estate roadway. The Committee consider that 30 lamps will be quite sufficient to light the principal outlying streets.

Kensington.—At the last meeting of the Kensington Vestry a letter was read from the secretary *pro tem.* of the Notting-hill Electric Lighting Company, inquiring whether it is probable that the Vestry will shortly notify their assent to the undertaking of that company, as they feel sure that not only their undertaking, but the residents in the district generally, will be prejudiced by delay. A letter was also read from the Kensington Court Electric Lighting Company, calling attention to the serious prejudice caused to the company by the delay in dealing with their application for powers to lay underground mains through an extended area in this parish, and asking that the approval of the Vestry may be notified with the least possible delay, especially as the whole question has still to be reviewed by the Board of Trade. Both communications were referred to the Electric Lighting Committee.

Austria.—The utilization of the electrical works at Salzbourg was recently initiated with 300 incandescence and 26 arc lamps. The installation, carried out by the branch establishment at Vienna of the firm of Siemens, comprises two horizontal tubular boilers, two steam engines of 100 h.-p., and three dynamos. The price per hour per incandescence lamp is four kreuzers (9·2 centimes).—At Gorlitz, the establishment of a central station for electric lighting is under consideration. Messrs. Siemens, of Berlin, have submitted a plan which, for an installation of 4,500 incandescence lamps, involves 500 steam h.-p., and an expenditure of 625,000f.—The firm of Ganz and Co., of Budapesth, has recently introduced the electric light in several theatres, notably in those of Riga and Odessa. In the case of the latter town, the central station supplying the theatre is at a distance from it of about 1½ kilometres.

Royal Meteorological Society.—At the ordinary meeting of the society, to be held by kind permission of the Council of the Institution of Civil Engineers, at 25, Great George-street, Westminster, on Wednesday, the 21st instant, at 7 p.m., an address will be delivered by the President, Dr. W. Marcet, M.D., F.R.S., on "Atmospheric Electricity," illustrated by experiments; after which Mr. G. J. Symons, F.R.S., will make a short communication on "The non-existence of Thunderbolts;" elucidated by accounts of searches after them and the exhibition of specimens. The meeting will then be adjourned, in order to afford the fellows and their friends an opportunity of inspecting the exhibition of apparatus connected with atmospheric electricity, including lightning conductors, photographs of lightning and damaged objects, and of such new instruments as have been invented and first constructed since the last exhibition.

Safety in Theatres.—Some interesting experiments to test the degree of security from fire afforded by the use of incandescence lamps were recently carried out by the Paris superior Committee on Theatres at the central laboratory of electricity at Grenelle, under the direction of M. Mascart, The lamps were successively applied to, and crushed to pieces in contact with, portions of scenery canvas, gauze, velvet, &c., but without any scorching or other appreciable effects. The most conclusive experiment was made with a piece of canvas which had been in use for ten years, and which was reduced to the condition of tinder by the heat of the gas lights. It was placed in direct contact with a 50 c.-p. Swan lamp for upwards of an hour, without producing any signs of combustion, scorching, or smoke. The Committee will shortly carry out another series of experiments before definitively deciding the question as to the absolute safety of a properly-devised installation of incandescence lighting.

Telephone Exchange for Godalming.—A meeting of the inhabitants of Godalming was held in the Masonic Hall, Godalming, on Tuesday, the 6th inst., to consider the proposal of the Equitable Telephone Association to establish a telephone exchange in Godalming and district. The Mayor (Alderman Stedman), in the unavoidable absence of the vicar (the Hon. and Rev. Canon Brodrick), presided, and after the meeting had been addressed by Mr. A. A. Campbell Swinton and Mr. Macpherson Grant, of the Equitable Telephone Association,

the following resolution was moved by Mr. E. Pullman, of Godalming, and on being seconded by Mr. E. Stedman, was put to the meeting and declared by the chairman to be carried *nem. con.* :—"That this meeting considers it, in order to keep with the times, desirable to establish a telephone exchange in Godalming, if a sufficient number of subscribers can be enlisted." The Swinton telephone instruments were fitted up for the occasion in connection with the hall, so that before they dispersed the visitors had an opportunity of testing them practically.

The Strike at Chelmsford.—Inasmuch as the mere mention of a strike frequently leads to mistaken opinion, we have endeavoured to obtain the real facts of the recent strike at Messrs. Crompton and Co.'s works, at Chelmsford. It appears that, by the command of the Union, men are not permitted to do piecework. A deputation from the men waited on the heads of the firm to explain their position in regard to the work and the Union. It is the intention of the Union not to allow piecework to be introduced into any of the new trades. Under these circumstances, Messrs. Crompton and Co. and the men agree to differ, and to part. The affair is simply and purely a question of "Union rules." The number of men employed by Messrs. Crompton belonging to the Union was very few, and there will be no difficulty in replacing them by non-Union men, nor will the firm suffer any inconvenience because of the defection. We are sorry that there should be imparted between masters and men any differences of opinion; but in these days of keen competition it is absolutely necessary that the masters should have the sole control of their shops.

Berlin Telegraphy.—Friday last will long be remembered as the busiest day on record at the Central Telegraph Office of Berlin. The pressure was great on Thursday, when 29,878 telegrams, aggregating 799,926 words, had to be sent off. But this record was eclipsed by the following day, no fewer than 36,615 telegrams, containing together 1,115,551 words, being despatched to all parts of the globe, and in different languages. All the Government telegraphists fit for duty had to be called in to meet the pressure, and all the available instruments were worked. It was a fortunate circumstance that the Berlin Bourse was closed, as this enabled the authorities to make use of the instruments there for the work. During the busiest hours of Friday last no fewer than 346 telegraphists were at work at the same time in the great instrument room of the Central Telegraph Office, and 230 instruments were operated. The above figures are startlingly high, no doubt, for Berlin; but would not be considered very wonderful at the central station of our G.P.O., where on one occasion—the day before the Jubilee day (June 20, 1887)—the total number of messages dealt with was no less than 124,291.

Bath.—Last week, at the Council Meeting, upon a proposition being made that the chandeliers in the Banqueting Room at the Guildhall should be repaired, at an expense of £30, Mr. Jolly moved an amendment to the effect that no expenditure be incurred at present, but that the Borough Property Committee be instructed to obtain plans and estimates for lighting the Guildhall with the electric light, using as a motive power the water now running to waste in the river, the property of the Corporation. He fully admitted all that could be said as to the handsome character of the chandeliers, but described the inconvenience which those who are in the habit of addressing meetings at the Guildhall feel from the almost blinding effect of the chandeliers, and also from the vitiated state into which the atmosphere quickly gets. He also suggested that sufficient power would be obtained by the means proposed to illuminate the market as well. Mr. Jolly's proposition met with the support of several members of the Council, and it would undoubtedly have been carried had it not been for the fear that the introduction of the electric light would necessarily mean the removal of the chandeliers. In the result the amendment was lost by 12 votes to 16.

Brilliant Illumination v. the Eyesight.—The opponents of electric lighting are apt to insist upon the ill effects of a brilliant illumination under conditions which, it is admitted, should be carefully avoided; but they comparatively seldom refer to the still more injurious effect upon the eyesight of an insufficient and unsteady light. This question was treated at considerable length by Dr. G. Sous in a paper "On the Electric Lighting of Theatres,' commenced in the second and ended in the third number of the present series. We quite endorse the following observations made by Dr. Morton at the last general meeting of the American Gaslight Association; but we fail to perceive that they have an application specially adverse to electric lighting such as has been attributed to them. "There is no doubt," said Dr. Morton, "that the present generation are risking their eyesight by the use of so many brilliant lights." He then pointed out that the eye requires *a thoroughly diffused light*, and alluded to the paralysing effect and ultimate injury to the organs of vision produced by frequent exposures to unscreened electric and powerful gas lights. Where it was found convenient or necessary to employ very powerful lamps, they should be placed well above the ordinary visual range, and shaded so as to produce a diffused and equable light.

Society of Arts.—The first of a short course of two lectures on "The Protection of Buildings from Lightning," was delivered by Prof. Oliver J. Lodge, F.R.S., on Saturday afternoon last. The lecturer began by giving a slight historical sketch of the subject, and called attention to the outstanding questions, difficulties, and points of controversy in connection with lightning conductors. He described the methods usually adopted, and showed that the reasons given for failure were often quite insufficient to account for it. An interesting experiment showed the effect of a minute quantity of electricity, and explained the reason of the large size of the rain-drops in thunder showers. As soon as a stick of sealing-wax rubbed on the coat-sleeve was presented in the neighbourhood of the jet of a tiny fountain, the drops previously falling in spray were collected, and fell as an almost continuous stream. In conclusion, the lecturer referred to the futility of ordinary galvanometer tests for lightning rods, and argued that the behaviour of a feeble battery current afforded no analogy whatever by which to estimate the effect of the explosive and shattering lightning discharge. At the second lecture on Saturday next, experimental answers will be given to some of the questions raised, and an endeavour will be made to supply a more complete account of the liability of conductors to side-flash than has yet been attempted.

Electric Lighting in France.—The Continental Edison Company has nearly completed the installation for the electric lighting of the Odeon Theatre in Paris, which is to be inaugurated on the 20th inst. It comprises 1,200 incandescence lamps, of which 1,000 are in ordinary use. There are three dynamos, each capable of working 500 lamps; the motive power for which is supplied by three Weyer

and Richmond steam engines, each of 70 h.-p. The same Company has, on the occasion of the production of a new piece, added 20 Jablochkoff candles to the installation at the Gaîté Theatre. At Boulogne-sur-Mer they have carried out an installation at the Casino, comprising 700 incandescence and 30 arc lamps; the latter being for the illumination of the gardens. The lamps are worked by two Edison dynamos, the motive power for which is 100 h.-p.—The *Compagnie Française d'éclairage Electrique* is carrying out considerable extensions at its station in the Faubourg Montmartre. It is now working over 1,700 lamps, and has signed contracts for the supply of 10,000 more. The present installation is capable of supplying 20,000 lamps.—The establishment of twenty-seven special telephonic lines connecting the Saint-Louis Hospital with call-stations in different quarters of Paris has just been authorised by the Government. By means of this arrangement, a special conveyance for the transport of patients to the hospital may be obtained within a few minutes in any of the districts in question.

Bournemouth.—Mr. W. E. Shakell, the secretary of the Bournemouth Electric Light Company, has written to the Commissioners for permission to open the roads for the purpose of laying down mains; and, at the last meeting of the Commissioners, the Roads Committee reported that they had asked for full particulars and plans as to what it was proposed to do in the matter. At the same meeting, on the recommendation of the Lighting Committee, it was resolved, in reply to a letter from Messrs. Phillips, Harrison, and Hart (offering to light the pier and pleasure grounds with electric light at costs varying according to the method adopted), to inform the writers that "the Commissioners are not prepared to entertain the matter at present." A further letter was read from the same firm, stating that they intended to apply to the Board of Trade for an electric lighting license for the district of Bournemouth, and, the clerk stating that such a license would give them power to open the roads, &c., it was resolved that the matter should be discussed at a meeting of the Commissioners on the 17th April, when they would decide whether they would consent to the proposed license. It seems that this application is very late in the day; besides it is well known that a local company, to whom Messrs. Phillips, Harrison, and Hart are altogether unknown, has been formed to carry out the lighting at Bournemouth; and in such cases, for such a purpose, a local company is far better than outsiders.

New York.—The *Daily News* correspondent telegraphs on Tuesday in regard to the recent terrible snow storm experienced in that city:—During Monday night also the electric light went out, and several persons were found frozen in the snowdrifts, while since the storm scores of injured persons have been taken to the hospitals. Seventy-five trains were stuck on the railway lines within a radius of fifty miles of the city. On the Western Union system half-a-dozen wires are working to the West, and communication is by this means maintained with the South, and with places up the coast. Direct communication with Philadelphia and Boston is still interrupted. Intelligence has reached here from the latter place, *via* London, stating that a terrific storm prevailed for two days, blocking the railroads and prostrating business. The storm is described as the severest known there for fifty years. There is some improvement in the railroad traffic here, but great interruption still continues. On Wednesday the *Financial News* correspondent cables:—"Private wires and telephones are alike useless, and the effect on New Yorkers, who are as much accustomed to the use of the telephone as they are to their daily bread, can hardly be imagined. We are completely snowbound, and shut off from the world, except by the Commercial Cable, which, unfortunately, cannot convey food or stores. Consequently the prices of coal and food are doubled to-day. The losses of the Western Union Telegraph Company, in repairs and loss of revenue, will be very heavy. The storm is abating, but the cold is intense, and traffic is still suspended."

Telephony at Macclesfield.—The Lancashire and Cheshire Telephone Company have now completed their operations so far as the local connection of the telephone is concerned, and during the past week the ten subscribing Macclesfield firms have been in daily communication. It will be some weeks yet before the trunk wire can be laid to Manchester and throughout the immediate district; when this is accomplished, subscribers will be able to communicate with the principal commercial houses in the two counties from which the Company derives its name, a boon which cannot be over-estimated. The central office of the company is at the *Courier* office. Should the undertaking receive sufficient encouragement from subscribers—and we have no doubt it will when the benefits are sufficiently well known—it is the intention of the company to establish a call office at the centre in Macclesfield, where, on the payment of a certain fee, the general public can communicate with any of the company's subscribers. The company have run free wires to the Macclesfield Infirmary and the Volunteer Fire Brigade. Up to the present time, connections have been established between 60 towns in Lancashire, Cheshire, and North Wales; while several towns in Yorkshire may be communicated with by arrangement with the National Telephone Company. The total number of subscribers approaches 5,000, and new names are being continually added to the list. Under the system pursued by this company, not only are any two members enabled to converse together, but it is also arranged that outsiders shall be able to communicate with each other by means of public call offices at various parts of each district. The co-operation of the Post Office has been secured in Manchester, Liverpool, and Blackburn, in order that telegrams may be sent to, and received from, the telegraph office, through the telepone, without loss of time necessarily occupied by the messenger.

The Electric Light in Paris.—A large number of petitions, praying for a prompt solution of pending questions in relation to electric lighting, have been laid before the Municipal Council. The trading classes in the quarters of St. Germain-de-l'Auxerrois, the rue St. Honoré, the place Vendôme, and the faubourg Montmartre demand the establishment of central stations; whilst the inhabitants of the quartier des Halles demand that the *Société d'Eclairage Electrique* in this quarter may be provisionally authorised to establish overhead cables. The most active interest, in fact, prevails in regard to the extension of electric lighting; and M. Lyon-Alemand, the reporter to the third committee, has, under these conditions, undertaken to send in his report immediately, with a view to expedite matters.—The fire which recently occurred in the underground portion of the Halles has had the effect of drawing the attention of the municipal council to the

danger of using gas in such localities. It has been urged by M. Lamouroux that not only from the point of view of the prevention of fires, but from those also of facilitating the work and preserving the health of the labourers employed in this market, a complete solution of the difficulty is to be found in the substitution of the electric light for gas. At the present moment a most favourable opportunity for so doing is to be found in the fact that it is proposed to construct works for the generation of the light in the underground portions of the meat pavilion. Unfortunately, the Administration and the committee of the Municipal Council are not in agreement as to the object and purpose of the works in question. The committee regard the lighting of the hall as altogether a secondary matter, and considers that the works should be devoted to the general distribution of the light in Paris. The administration, on the contrary, consider that the proper way of commencing business would be to provide adequate illumination for the market itself. It is to be hoped that this difference of opinion will not have the effect of retarding the construction of the works, which are urgently required. In the meantime the electric light has been actually introduced in certain portions of the underground premises which are being restored, and where the installation of gas would, in the opinion of the Administration, be disadvantageous. An electrical installation has therefore been provisionally carried into effect; for which, on the motion of the Prefect of the Seine, the Council has voted a credit of 25,000fr.

Liverpool Electric Co.—The annual meeting of the Liverpool Electric Supply Co. (Limited) was held on Monday, Mr. Arthur Hill Holme in the chair. The report and accounts were passed, and a dividend of 7 per cent. for the past year was declared, and an addition made to the reserve fund. The retiring directors, Mr. S. H. Holme and Mr. D. de Ybarrondo, and Mr. W. L. Jackson, auditor, were re-elected. Commenting upon this meeting, the *Courier* says :—"In 1883 the Liverpool Electrical Supply Company was formed, apparently as a sort of tentative effort to give the electric light a permanent local home. The experiment has succeeded. The original capital was £10,000, but the business expanded and the capital was increased to double that amount, and it will be seen that at the meeting yesterday the directors agreed upon a dividend of 7 per cent. This circumstance suggests that there is not only a demand for the electric light, but that this demand can be met with substantial profit to the shareholders. Under these circumstances it is not surprising to note that the company have decided to make their business more commensurate with the requirements of the city. To this end they are increasing their capital to £200,000, including the shares to the value of £20,000 already subscribed, and they intend to supply the electric light to all who seek it within a very wide area, comprising the more important residental parts of Liverpool as well as the great business centres It is arranged also that the supply shall be by day and night at a regular fixed charge, measured by meter. There has been a supply station in Rose-street for four years, and a second station has recently been started in Tithebarn-street; while a third and more important one is approaching completion in Harrington-street. Besides the use of electricity as an illuminant, it is naturally expected that its utility as a motor will become more generally recognised when it is brought within reach of those who need 'power' for trade or other purposes. There is one circumstance that must secure for the company's prospectus a careful consideration on the part of the public: the ten-fold enlargement of the undertaking is promoted by responsible Liverpool gentlemen, who are fortified by the experience already gained. With a capital of £10,000 the dividends were 5 per cent., while with a doubled capital the dividends have reached 7 per cent.—a fact which seems to indicate that proportionately larger profits may be expected from the further extension of the business. The enterprise is of importance to the whole community, and not merely to the investing portion of it, and its development will be watched with considerable interest.

Royal Colonial Institute.—A meeting of the Royal Colonial Institute was held on Tuesday evening at the Whitehall Rooms of the Hotel Metropole, when Mr. J. Henniker Heaton, M.P., read a paper on "The Postal and Telegraphic Communication of the Empire," of which we can for the moment give only the following brief abstract. The chair was taken by Viscount Bury, and there was a large attendance. In the course of his paper Mr. Henniker Heaton expressed the opinion that the Imperial and Colonial Governments should unite to acquire all the existing Imperial telegraphs, and to construct what other lines might be deemed necessary. He thought that telegrams could be profitably sent between England and Australia for 1s. a word. The Pacific cable could easily be made to transmit 10 million words a year. That alone would give a revenue of £500,000 a year, sufficient to bear its share of the interest on capital, to pay the working expenses, and to leave a margin of profit. Looking back upon the past, they saw every reason for encouragement. It was only 50 years ago that a few scientific men made the experiment of electric transmission between Euston and Camden Town, in the north of London—a distance of about a mile. The jubilee of the telegraph had just been celebrated in the capital of the Empire. Australia was not connected with the telegraphic system of the outside word till 1871. To-day messages were transmitted between London and Dublin at the rate of 462 words per minute. The number of telegrams sent through the post offices of the United Kingdom averaged nearly a million a week; and between any two points within the United Kingdom a telegram could be sent for sixpence. There were now 115,000 miles of submarine cables—as much as would go round the world five times; and a message could be sent all round the world in twenty minutes. Those cables carried a hundred million words every year. He saw that the accidental reduction in the rate between England and America had led to an increase of 150 per cent in the traffic. "Hands across the sea" would indeed be no figure of speech when almost the poorest would be able to communicate, momentarily, with his friends at home, and they with him. Whether for the purpose of maintaining old friendships, old relationships, the ties of home and kindred—whether for developing the exchange of produce and of manufactures, so that each separate part of the Queen's dominions should partake of the other's wealth, to the increased prosperity and happiness of them all—whether for defending this great but scattered Empire against those who might disturb her peace and check her career of tranquil progress—there had never yet been devised so sure an agency as the throb of the electric pulse, signalling with unfaltering regularity, night and day, the thoughts and wishes they would impart to their fellow-subjects in every clime, bringing them near in spirit though not in body, and effecting that unity of interest and sympathy in which were mainly laid the foundations of the British Empire.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 200.*)

Resistance Slides.—In the use of the different forms of resistance boxes, which have been described above, the Wheatstone's bridge is generally made up of the resistance to be measured; two constant resistances, and one variable resistance, together with the battery and the galvanometer circuits. It is quite clear that instead of using two constant and one variable resistance we might use one fixed resistance, and vary the ratio of the other two until balance is obtained. When proper arrangements can be made for the purpose this method is convenient and accurate, and allows the balance to be very quickly obtained. The arrangement is illustrated diagrammatically in Fig. 10, in which R is supposed to be a set of resistances of any convenient form, to be used as the invariable side of the bridge during any one test; but capable of variation, so as to be suitable for the measurement of different resistances. One end of the resistance R is connected to the end A of a set of equal resistances A B (a Thomson's resistance slide) and the resistance x, the magnitude of which is to be measured, is connected between the other end of R and B. The battery E and the galvanometer G may be supposed connected up as indicated in the diagram. When a single slide is used it usually consists either of ten or of one hundred equal resistances

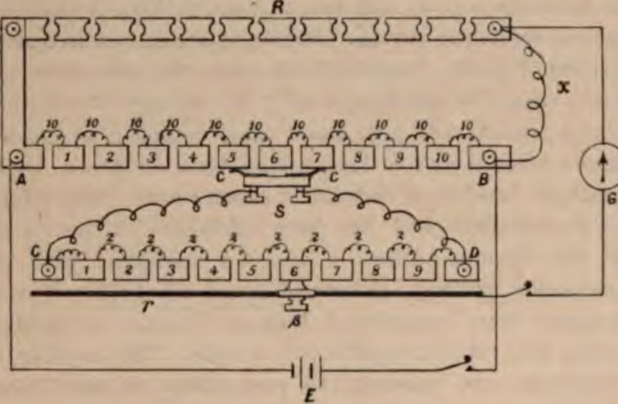


FIG. 10.

and a slider such as that shown at s is arranged on a slide rod r fixed in front of the blocks, which connect the resistances in such a way that when the slider is moved backwards and forwards it puts the galvanometer in contact with the different blocks in succession. When measuring a resistance in this way the resistance R is made nearly equal to the estimated value of x, the battery and galvanometer circuits closed and the slider moved until the galvanometer deflection is nearly zero. If the slider is near one end of the resistance slide R should now be readjusted so as to be more nearly equal to x, and the position of s, which gives no current through the galvanometer, found. If no such position can be found then the two adjacent positions which give opposite currents through the galvanometer should be found, and the galvanometer deflections noted. Let a and $a + 1$ be the numbers of the blocks in these two cases, and let d and d_1 be the galvanometer deflections. Then the position of the slider which would have given zero deflection is on the resistance between a and $a+1$ at a distance $d/(d+d_1)$ of its length from the end connected to the block a. Hence the proper reading for the position of the slider would be $a + d/(d + d_1)$, and assuming n resistances in the slide, the value of x would be obtained from the equation

$$\frac{R}{x} = \frac{a + d/(d + d_1)}{n - \{a + d/(d + d_1)\}}$$

or

$$x = R\frac{n - \{a + d/(d + d_1)\}}{a + d/(d + d_1)}.$$

In the arrangement illustrated in Fig. 10 a double slide is supposed to be used. In this case the slide A B consists of eleven or of one hundred and one resistances, while the second slide C D consists of ten or one hundred resistances the aggregate magnitude of which is double that of each of the resistances in the slide A B. The ends of the slide C D are connected to a double contact slider S, the two contact springs c_1 c_1 of which are insulated from each other. The contacts of the slider S are made to embrace two of the resistances in the slide, so that the total resistance between the ends of A B is always either ten or one hundred times the resistance between a pair of adjacent blocks.

The second slider thus forms a vernier by means of which the position of the slider S, which gives an exact balance of resistance, can be more nearly obtained. Suppose an exact balance has been obtained with the sliders S and s, in the positions shown in the diagram. Then the value of the resistance x is

$$x = R\frac{100 - 56}{56} = R\frac{44}{56}.$$

When exact balance cannot be obtained, the proper position, intermediate between two contact blocks, for the slider s is to be calculated from the deflections of the galvanometer, in the same manner as has already been indicated for the case of a single slide. This vernier principle might be still further extended, and triple or quadruple slides used, in which case, if the last slide contained n resistances, each equal to w_1, the next would contain $n + 1$ resistances, each equal to $\frac{n\,w}{2}$; and the next $n + 1$ resistances each equal to $\frac{n}{2} \times \frac{n\,w}{2} = \frac{n^2}{4}\,w$, and so on.

It should be observed, however, that when only one slide is used the resistance of the contact between the slider and the block or the slide rod r is in the galvanometer circuit and does not affect the accuracy of the result, but when a vernier is used the contacts of the slider S form part of the resistance of the vernier slide, and hence may introduce error in the result. It is not advisable therefore to push this vernier method so far as to make the resistance of the last slide less than 10 ohms or so. The form which is most convenient and most commonly adopted for these slide resistances has a circular row of contact studs and a contact arm which revolves round an axis at the centre of the circle. The main slide has in this case a double contact arm to which the vernier slide is connected. These circular slides generally contain one hundred or, if it is a main slide, one hundred and one separate resistances, each of which is either 100 or 1,000 ohms in the main slide and 2 ohms or 20 ohms in vernier slide. In the use of such slides for the measurement of resistances it is important to bear in mind that the greatest sensibility of the slide arrangement is obtained when the main slider is so placed that equal ratios can be obtained, that is, when S bridges from 4 to 6 and the vernier s is at 10, or when S bridges from 5 to 7 and s is at zero. Passing from this position we get the following ratios in succession :—

1 to 1·0000
1 to 1·0408
1 to 1·0833
. . . . .
1 to 32·333
1 to 49·000
1 to 99·000
1 to infinity.

From this table it is quite clear that a slide resistance can not be used with advantage when the ratio of the fixed resistance to that to be measured differs much from unity. It may be remarked that several short slides joined up so that each acts as a vernier on the one before it, is for the same range more economical of contact studs and resistance bobbins than two long slides. Thus, three slides, each with eleven resistances, and one of ten resistances, give, when properly joined up, the same range as two slides of 101 and 100 resistances; while in the first there are only 43 contact studs, and in the second 201. For multiple slides in this form straight slides have an advantage in compactness over circular ones. Thus, an arrangement containing five slides of eleven resistances, and one slide of ten resistances, can

be arranged on a moderate-sized rectangular box, and gives great sensibility through a considerable range of the main slide. Each of the main resistances may have 1,000 or 10,000, or 100,000 ohms resistance according to the purpose for which it is intended. With an arrangement of six slides, the main slide resistances require to be at least 1,000 ohms, so as to avoid error due to resistance of contacts in the last slide. When the slides are arranged for equal ratios in the bridge, each step of the last vernier makes a change of only two five hundred thousandths in the ratio, while with the slides arranged for a ratio of 9 to 1 each step of the last vernier makes a change of ten five hundred thousandths in the ratio. Hence such a slide gives ample sensibility through a range of from one to ten on the main slide or for the measurement of resistances varying from a tenth to ten times the fixed resistance. Slide resistances of the form just described are convenient for the measurement or the comparison of high resistances and, as we shall find later, for the measurement of capacities, but when the resistances to be measured or compared are small it is much cheaper and better to adopt some arrangement which has a small total resistance and which at the same time admits of a continuous variation. Such an arrangement is Kirchoff's wire bridge illustrated in Fig. 11. It consists of a wire A B stretched in front of a scale of equal divisions and securely soldered at each end to thick copper straps which are screwed to a base of dry wood. The copper straps are usually made of the form shown in the figure, passing along behind the scale, leaving four gaps which may be closed either by resistances as indicated in the figure, or by strips of copper made with notches to fit under the binding screws, which are represented by the double concentric circles in the figure. The wire forms the slide and is, in this form, usually one metre in length between the solderings. The wire may be of almost

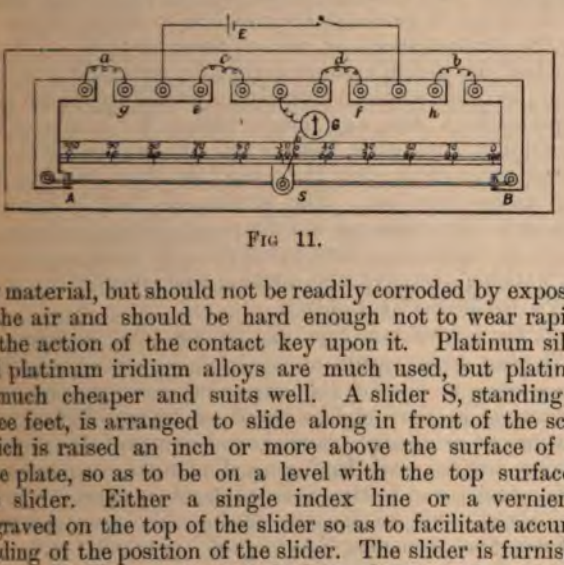


FIG. 11.

any material, but should not be readily corroded by exposure to the air and should be hard enough not to wear rapidly by the action of the contact key upon it. Platinum silver and platinum iridium alloys are much used, but platinoid is much cheaper and suits well. A slider S, standing on three feet, is arranged to slide along in front of the scale, which is raised an inch or more above the surface of the base plate, so as to be on a level with the top surface of the slider. Either a single index line or a vernier is engraved on the top of the slider so as to facilitate accurate reading of the position of the slider. The slider is furnished with a binding screw attached to the top of a vertical metal rod, the bottom end of which is sharpened and can be brought into contact with the wire by pressing on the top of the binding screw. This bridge is usually connected up as shown in the diagram, where E is the battery and G the galvanometer. The battery circuit is shown interrupted by a single lever key, but in this as in all other arrangements of the kind, it is preferable to use a reversing key. The length of the slide is increased at will by the introduction of resistances a and b in the two end gaps. For most purposes for which this bridge is used a and b are equal, but they may have any ratio which may be required, depending of course on the ratio of the resistances to be compared. The resistances to be compared are shown at c and d. Suppose in the first place that c is nearly equal to d. Then a and b are made so nearly equal that the middle of the total resistance a, b, and the slide wire and its connections, is near the middle of the wire. The position of the slider S is found, which gives no deflection, when the circuits of E and G are both closed. The resistances c and d are then interchanged, and the position of S again found, which gives an exact balance. These positions should be equal distances on opposite sides of the middle of $a+b+$ A B, and if the value of one division of the wire in terms of the whole resistance in its circuit is known, the ratio of c to d can be at once calculated. The case here considered is the one of most common occurrence, because such a bridge is generally used for the comparison of standards or other resistances of equal value. In order that the method may be convenient, it is necessary either to have a perfectly uniform wire, or to know the relative value of its different parts, and also the percentage value of unit displacement along the wire. Methods of finding the relative value of the different parts, or calibrating such wires, will be given below. The percentage value of unit displacement, with any particular resistances a and b in the circuit, is best found as follows. Substitute for c and d two known resistances taken, let us suppose, from a box of resistances. Find the position of S which gives a balance; and then, increase one of the resistances in the box by the addition of a small known resistance, and again find the balance. The percentage value of the displacement of S is then the same as the percentage change made in the ratio of the resistances. Take, for example, an ordinary resistance box; and, c and d being removed, join in, by means of the terminals e and f, the resistances a + b + A B, and the connecting pieces, as if their total resistance was to be measured. Join the galvanometer circuit from the slider S to the junction between what is usually taken as the variable resistance in the box and the divided resistance. Now employ one of the hundred ohms of the divided resistance and one hundred ohms in the box and find the position of S which gives a balance, then increase the resistance in the box by one tenth of an ohm and again find the position of S which gives a balance. Let the number of divisions S has been moved between the two experiments be n. Then a displacement of S by n divisions from the middle position indicates, in the ordinary use of the bridge, a difference of one tenth per cent. between the two resistances c and d. The values of two tenths, three tenths, and so on may be found experimentally in the same way,

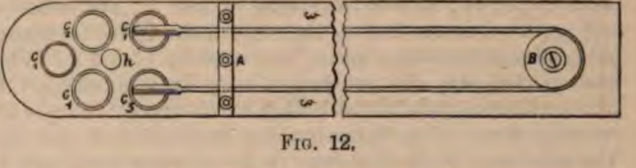


FIG. 12.

or if the wire be calibrated they may be calculated. It must be remembered that the displacement for two tenths is not quite double that for one tenth, because the sensibility becomes less and less as we approach the end of the slide. It must also be remembered that when double readings are taken by interchanging c and d, half the displacement of S is the displacement from the centre. When the wire is calibrated the experiment just described gives the means of calculating the effective total length of the wire in scale divisions, and hence it is better in this case to calculate the ratio of c to d from the readings on the scale. Suppose with c and d placed as in the figure the slide is found when balance is obtained to be n divisions from g, and when c and d are interchanged it is m divisions from g. Then $c/d=n/m$, when the resistances c and d are not nearly equal, and their value either actual or relative is wanted accurately, it is better to compare them separately with known resistances to which they are nearly equal. If their relative value is only wanted approximately the additional resistances a and b may be dispensed with, and the ratio found directly by means of the wire itself. For use in this way the connecting pieces between the battery and the ends A and B of the wire should be included in the calibration, so that no estimation of their value is required. When the resistances to be compared are low and great accuracy is desired, as for instance, in the comparison of standard ohms, it is advisable to introduce the resistances by mercury cups instead of binding screws. The mercury cups should either be wholly of copper or have copper bottoms, and the ends of the resistances should rest against the copper, the mercury being used only to insure contact. A convenient and inexpensive form of wire bridge is shown in Fig. 12. It has the great advantage that it can be made up by the user with little trouble and is capable of giving

very accurate results. A wire, w, which may be copper, but preferably of German silver or platinoid, is stretched on a board, or a table, round an insulating block B and held by a clamp of vulcanite A placed at a short distance from the ends. The wire should not touch the board or table, but be suspended above it by means of A and B, or, if it be made long, by means of several clamps like A. A nest of mercury cups, C_1 C_2, are placed in a block of paraffined wood or vulcanite fixed to one end of the board, in such a way that the level of the tops of the mercury cups is about the same as that of the wire. The end of the wire is soldered to a thick rod of copper, bent in the shape shown in Fig. 13, and well amalgamated with mercury. The reason for bending the rod in this way is to prevent the mercury touching the soldered junction.

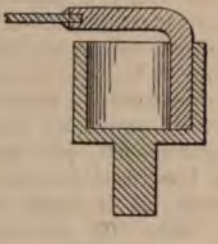


FIG. 13.

The mercury cups may very conveniently be made of copper, of the shape and size shown in Fig. 13, and fitted into holes in the wood or vulcanite. They can then be lifted out and emptied, or they can be used for another instrument if required for such a purpose. A number of cups of this form are exceedingly convenient, either for a laboratory or for a testing room. Should greater sensibility be required than is obtained by the bridge wire alone, auxiliary resistance may be introduced between c_1 and c_2, and between c_4 and c_5; while c_2, c_3, and c_3, c_4, are joined by the resistances to be compared. Since w can be made several metres long in this case, the auxiliary resistances are not often required; and in this case c_2 and c_4 are removed and c_3 placed in the hole h, the resistances to be compared being placed between c and c_3 and between c_3 and c_5. When used in this way the resistances may be interchanged by lifting the two ends of the bridge wire out of the cups and crossing them, thus interchanging the sides of the wire. The wire may be divided into parts of equal resistance by calibration marks made on the board at the different divisions, and a movable scale used to subdivide the sections between the calibration marks.

INDEPENDENT ENGINES IN INDEPENDENT STATIONS.*

BY WILLIAM LEE CHURCH.

The service of electric lighting differs from other forms of manufacture in requiring more horse-power per square foot of floor space; in requiring higher speeds; in demanding the power in larger units; in compelling a closer and more uniform regulation; and in requiring more rapid and constant extensions. It will be observed that these peculiarities require individual and special treatment in the generation and distribution of power, and engineering practice as determined in other means of manufacture may be sadly at fault when applied to electric lighting.

It has become an axiom among experienced station managers that the money is made or lost between the shovel and the belt; in other words, other things being equal, the dividend-earning capacity of a station is determined by its steam plant, to which the electric apparatus is in the nature of an accessory.

Incandescent lighting has not until recently made a brilliant record as an investment, and much of the disappointment is directly traceable to the culpable ignorance of the principles of steam engineering which has been displayed. A man who will not venture to cut himself a 2.00dols. vest will not hesitate to exercise his amateur talent upon a steam plant, upon the economical and reliable performance of which depends an investment of 100,000dols. and the public service of a city. A long and critical experience in this branch of industry has grounded us in the conviction that no incandescent station can hope to be financially successful, under the ordinary conditions of competition, unless based on independent dynamos belted direct from independent engines. Throughout this paper, therefore, we desire to keep constantly in view the opposite systems, namely, a station containing a given number of dynamos of two or three different capacities, each belted direct from high-speed engines of corresponding rating, and, on the other hand, the same station with the dynamos driven from one or two slow-speed engines transmitting their power through one hundred feet of shafting, more or less, encumbed with clutch pulleys. Having these pictures well in mind, we inquire—

What are the essential requirements of a first-class steam plant in an incandescent electric light station? Taking them up in the order of their importance we unhesitatingly say first, and always foremost, *absolute reliability for continuous running.*

The electric light company contracts to supply the demand of a diverse and exacting public, and that public expects to find its light on tap at every moment of every hour of every day in the year. Failure of service in ever so small a degree is palliated by no excuse. Complete reliability is the condition of popularity, confidence, and patronage, without which all the other economies and excellencies go for nothing.

Again, electric lighting, perhaps more than any other industry, has its earnings directly affected by the shutting down of its power, since it sustains a direct financial loss for lights out, aside from custom and reputation, not easily regained. Subdivided power reduces this risk to a minimum, and, properly directed and applied, obviates it altogether. In a station using, say, 2,000 horse-power, say in the shape of two large engines, loss in lamps in one night by the shutting-down of one of these engines is equal to one-half the cost of an independent engine on the subdivided plan; in other words, as tersely expressed by a manager of experience, a company might better, for peace of mind, reputation, and cash balance on the books, throw a 60 horse-power engine into the scrap pile than to shut down the station one hour. The service of electric lighting is similar to the editing of a daily paper, in that lost time can never be regained. Most industries can make up lost time by working overtime, and pushing their business in various ways, but in electric lighting—

"The mill will never grind with the water that has passed."

Passing from argument to instance, we cite the recent experience of one of the largest stations in the country, operating in the neighbourhood of 20,000 lights. This station, as originally planned, was driven from a pair of Corliss engines, each having a cylinder 28in. in diameter by 48in. stroke, and belting to a countershaft 4½in. in diameter by about 50ft. in length. From this countershaft are driven five dynamos, having an aggregate capacity of six thousand 16 candle-power lamps. Clutch pulleys 8ft. in diameter, which are the means of disconnecting the dynamos when not in use with similar clutch pulleys for exciters. The remaining dynamos in the station are each of 2,500 lights capacity, and each driven by a 200 horse-power independent engine belted direct. Recently, in the middle of the heavy run of the evening, one of the clutch pulleys broke in some of its parts, necessitating the immediate shutting down of the 6,000 lights, besides doing considerable damage and involving danger to the *employés*. The extinguishing of such a large number of lights at the important hour of the run was a blow at electric lighting of the severest nature, and working serious inconvenience to public gatherings. It happened that one of the independent engines, with its dynamo, was immediately available, and was started within two or three minu[tes] so as to take up a portion of the load of the large engine. In t[he] same station, at a subsequent time, a key became loose on the valve gear of the engine, necessitating another stop [of] several minutes. On still a third occasion the crank became uncomfortably hot, and was carried through the r[un] only at a great risk and labour. This illustration is used [as] one among many of the almost evident fact that no elec[tric]

* Paper read before the National Electric Light Association.

on can afford to hang its whole business upon any e of motive power, particularly when that motive distributed through the complex mechanism ershafting, clutch pulleys, &c., involving a ot bearings, broken pulleys, defective frictions, t not, any one of which may shut down le station. Had these dynamos been each om an independent engine, the accidents above ed could not have occurred in the nature of the e do not assume to say but that accidents of some e due in any piece of mechanism; but the division and generating capacity into comparatively small h independent of all the others, affords a practical distributing the danger, so that it is essentially effects; that is to say, had a stoppage of any one ent engine in a similar instance occurred from any other engines, with their dynamos, would easily ributed the load for a short time, without any ce or danger whatever, and the service would have nterrupted while the repairs were being made or lties remedied.

been incidentally remarked by a gentleman vith the practical operation of a station, that ent engines afford a safeguard against danger from uits, inasmuch as currents of the short circuit will an independent engine and slow it down, thus rning of the danger. If the dynamo is driven ngle large engine, motive power will not respond rt circuit until the short circuit becomes equal to capacity of all the connected dynamos plus the power in the engine. Practically, therefore, an this type will not feel the short circuit, but will rough until something burns away.

rit of the steam plant which is most obvious, and peals most strongly to the electric light company *of fuel.*

vocates of large slow-speed engines rely upon the superior fuel of this type as the sole effect to its isadvantages. All managers unhesitatingly admit riority of transmitting the power directly and oss from the engines to the dynamos, and more or ly concede that in its performance the high-speed ll also equal the running qualities and durability w-speed engine. If with this, say they, we could team efficiency of the Corliss engine, no man sitate to decide in the favour of the convenient, and independent small engine. We take the at once by the beard, and desire to state that, ncandescent stations operating under ordinary nces, and otherwise equal, except only in their d transmission, that one which has independent ted engines will show on its monthly report sheet, ll amount, but from one-third to one-half less coal hour than a station driven from a single engine ountershafting, both types of engines being non- g. We go yet further, and state that independent nsing engines, under many conditions, will about monthly coal account an equivalent slow-speed g engine. This is a fact so incontrovertible, when nd candidly investigated, that we do not propose emonstrate, but merely to illustrate it.

w submit the prompt inquiry, "Will not a high- ine use more coal per horse-power per hour than engine?" Yes. "How much more?" Size for load for load, not over 10 to 12 per cent. Score nt. against the high-speed engine, and again ask, t several small engines use more steam that one t large engine, even of the same type?" Yes. uch more?" Load for load, possibly another 10 Score 20 per cent. against the high-speed engine, ask how an admitted loss of one pound of coal in e can be reconciled with the statement of a monthly f 30 to 50 per cent. in favour of independent Answer, simply because we have to deal with s as they exist in fact, and not as we assume them

ason why independent engines can overcome their lack of initial economy, and pass a large percen- ctual economy to their credit, are mainly two. use of a countershaft implies power to run it. Indicator diagrams show that the real load of such a plant varies from 12 to 20 per cent. of the gross horse-power under full load when in ordinary good condition, and not infrequently rises to 30 per cent. and over, with badly lined shaftings and badly drawing pulleys. Moreover, it must be borne in mind that the dead loss is nearly a constant quantity, and if it amounts to 20 per cent. of the full load it will under partial load equal, and even exceed, the net power transmitted to the dynamos. It may easily happen, and doubtless does happen every night in every station thus far, that from midnight to morning two or three horse-powers are expended in the cylinder for each effective horse-power recovered at the dynamo pulley.

Thus, by one stroke and by a single item, is the conceded advantage of the larger engine reckoned in coal per horse-power, practically swept away, and large and small engines left standing on an equal footing, prepared to submit to the still more searching question, "What is the cost from hour to hour of the power actually expended in meeting the fluctuation of the load?"

To consider for a moment some abstract fact in steam engineering, we must note that the steam engine develops its maximum economy (*i.e.*, minimum consumption) only over a limited range of its power. Under normal conditions of pressure, say eighty to a hundred pounds in the boiler, this minimum consumption is found only between the points of $\frac{1}{5}$ and $\frac{1}{4}$ cut-off. At its rated power, therefore, the single large engine of the Corliss type will consume as little as 26 to 28 pounds of water (steam) actually fed to the boilers per indicated horse-power per hour; and if the economy were not affected by the load, we could represent the rate of consumption by a straight line. If overloaded, however, the rate of water consumption rises, in which horizontal distances on a diagram represent the actual points of water consumption; the curve, therefore, being a curve of efficiency at varying loads, it will now be particularly noted that, when the load rises for an overload, it also rises for an underload, and very much more rapidly. This is well understood to be partly from excessive condensation due to over expansion, and partly from the greater ranges of leakage under short cut-offs. Considering the actual performance of a 400 horse-power engine at varying points of cut-off, the engine can be at its best only over a limited range—say, from 325 to 400 horse-power. An overload is, of course, mechanically injurious which limits the possibilities in that direction. As the load falls off below $\frac{1}{5}$ cut-off, the steam rate increases at an enormous ratio; so that at 200 horse-power the engine is using 50 per cent. more than its normal rate—*i.e.*, at 200 horse-power it is actually using the gross amount of steam which would give 300 horse-power if used in a 300 horse-power engine. At 100 horse-power, waste is fully 100 per cent.; and the steam used should develop, not 100 horse-power, but 200 horse-power, if used in a 200 horse-power engine.

It now remains to determine if the conditions actually obtained in electric lighting stations are such as will enable a single large engine to develop its normal economy; and, if not, then they are such as will enable the smaller independent engine, with a lesser initial economy, to reach a better gross result, under the inevitable conditions as they are found to exist.

(To be continued.)

EARLY TELEGRAPHY.

Some interesting information has recently been given by Mr. T. Home, relative to the first telegraph on the Great Western Railway from Paddington to Slough. We shall allow Mr. Home to give his experience in his own words :—

In 1842 the Directors of the G.W.R. very kindly and very generously—regarded by Mr. Cooke as such, I well know—gave Messrs. Cooke and Wheatstone permission to lay down their telegraphic wires from Paddington to Slough for experimental purposes. In the first instance Mr. Cooke used four copper wires, thickly covered with cotton (like that used for ladies bonnets), and unitedly drawn through a resinous solution, and finally secured in 1in. iron pipes which he slightly buried below the surface on the near side of the down rails from Paddington to Slough. The insulation, however, by this plan of conducting the wires proved imperfect, which no doubt was caused by

the displacement of the resinous coating, and probably that also of the cotton, by the friction in drawing the wires through the pipes. This difficulty for a time appeared a formidable one to Mr. Cooke, and gave him great anxiety, interfering as it did with correct signalling, but he very shortly overcame it by procuring a quantity of foreign poles, 15ft. or 16ft. long, to which he suspended the wires as now done, and used brown earthenware insulators at the points of suspension to the posts as now. The insulation was then found to be all that could be wished, and signals were then sent with great rapidity and unerring fidelity.

Up to March, 1843, suitable offices had not been provided for the use of signalling, but immediately after that date the directors of the G.W.R. very generously provided suitable office accommodation for the patentees, both at Paddington and Slough stations, and I consider the public is greatly indebted to the thoughtful generosity and kindness of the said directors for the early introduction of electric telegrams, owing to the facilities rendered by the directors to Messrs. Cooke and Wheatstone in carrying out their experiment on a more extended scale than they had been able to do.

I am much indebted to Mr, Higgins, of the G.W.R. Company, Paddington, for the following information, which he has kindly procured for me at a vast amount of trouble in searching the Company's records:—

"G.W.R., London Terminus, Paddington,
"March 8th, '87.

EXTRACT.

"Reference has been made in our records, and the first mention of the subject was in March, 1843, when, on the application of Mr. F. Cooke, authority was given by the directors for the erection of offices at Paddington and Slough stations for the purposes of the Electro-Magnetic Telegraphs. "J. D. HIGGINS.

"To Mr. Thos. Home, The Kilns, Brill, Bucks."

Some of your readers may probably recollect that the telegraph offices referred to were located as follows. That at Paddington Station was the first room on the right at the top of the stairs leading to all the principal offices of the Company at the arrival platform, and that at Slough stood on the summit of the mound, planted with shrubs, near the railway bridge on the right on leaving the station for Windsor.

Suitable offices having been secured, the patentees were in a position to send any telegrams required either for the G.W.R. Company or the general public. As the G.W.R. Company did not care to purchase this line of telegraph, as Mr. Cooke had hoped they would, and as Mr. Cooke was naturally very anxious to get some return for the very heavy cost that he had incurred up to this period, I suggested to him that he should let the telegraph in question to me at a low rent, and I would open the offices at Paddington and Slough to the public as an exhibition at a small entrance fee, and would send any telegrams required at a small charge. This suggestion met with Mr. Cooke's entire approval, and I forthwith entered into possession as "Licensee" at a rental of £170 a year, with the understanding that all telegrams the G.W.R. Company required to send were to be free, as some slight return for the kindness of the directors in giving the patentees the free use of their line for experimental uses. This privilege of free telegrams was only used on special occasions. I continued "licensee" until the patentees sold their several patent rights to the Telegraph Company, floated in 1846 to extend its ramifications.

Having entered on my unique undertaking as "licensee" of the grandest, most wonderful, and certainly the most valuable and interesting discovery of the age, I lost no time in making known to the public, through the best recognised channels, the fact that the telegraph offices at Paddington and Slough were open to them on payment of 1s., and that telegrams could be sent for 1s. each, messenger extra. With the kind permission of the G.W.R. directors I had large posters displayed on the walls of all their stations, the like displayed by many tradesmen outside their shops in various parts of London, engaged the services of a small regiment of those apparently indispensable "sandwich" gentlemen well equipped with handbills for judicious (?) distribution in their perambulations of the great highways centreing to the City; and finally by causing advertisements to appear in the leading London daily and weekly papers, the editors of which rendered me good service by every now and then kindly notifying to the public that 1s. spent in paying a visit to Paddington and Slough offices could not fail to ensure the most gratifying results. I name this to show your readers the steps taken by me, and at my sole cost, to bring the merits and capabilities of the telegraph well home to them, and in doing as described, I no doubt rendered the patentees good service by at least aiding to hasten its general adoption, which shortly after resulted; your readers, however, must feel surprised when informed that my undertaking signally failed in the realisation of that big pile I had fondly hope would be an accomplished fact in the near future. Young and inexperienced I had unfortunately formed to high an estimate of public taste, as evidenced by the extensive patronage accorded other exhibitions of incomparably less merit. Nevertheless, pleasure even at this distant period is derived by a retrospect of the many incidents of my telegraphic days, and from the fact that I have had the honour—if empty—of explaining the working arrangements of the various telegraphic instruments then patented by Messrs. Cooke and Wheatstone to the most eminent men of the day, including the bulk of the aristocracy and several of the crowned heads of the principal European countries when on a visit to this country during the years 1843 to 1846.

The honour of having sent the first paid telegram in this country is due to myself beyond doubt, and it has occurred to me as a singular coincidence that the charge made for the first telegram should be the same as that fixed by the Postmaster-General. However, there is this marked distinction, I never limited the sender to number of words. No reasonable person, however, will find fault with the present charge for inland telegrams.

The first electric telegram sent in this country specially on behalf of Her Majesty Queen Victoria was received by me at Paddington Station, from my Slough correspondent soon after 4 a.m. on the 6th August, 1844, which was to request me to forward letters I had long previously received from Windsor Castle to several respective addresses, and which were to summon the Cabinet Minsters to Windsor Castle so that they might have the honour of being introduced to H.R.H. the Duke of Edinburgh, whose advent had been foretold just 23 days earlier, and during which 23 days and nights I had been made an involuntary prisoner in the Paddington telegraph office, anxiously awaiting instructions as to the said letters, which in due time I despatched by special messengers in cabs; and to the credit and loyalty of the said Ministers, it should here be stated that they began to arrive at Paddington station within an hour and a half of my receiving the telegram. Those first to arrive paid me a visit to see the telegraph (while waiting the arrival of others), and expressed, as all did, the greatest pleasure in seeing it worked. One noble lord, on learning the length of time I had been made "prisoner during Her Majesty's pleasure," told me he should certainly bring the fact to Her Majesty's notice.

Three special trains were requisitioned that morning to convey the Ministers to Slough *en route* to Windsor Castle. The last of the three trains had one minister only, and, unless my memory fails me, that was no other than the Iron Duke, whose train accomplished the journey, 18½ miles, in 18½ minutes. The driver of the Flying Dutchman and others will take note of this, and may rely on it as a fact.

During the last four or five days and nights of anxious waiting I was honoured with the company of the representatives of each of the following papers:—*Times*, *Herald*, and *Post*, who, on being put in possession of the particulars of the birth of His Royal Highness, took their departure to their respective offices, and the long-looked for news appeared on the breakfast table of Londoners in the shape of a second edition. I name this to show the heavy sacrifices made by newpaper proprietors to secure the first intelligence of interest for their respective customers. I made no charge for the information, but was substantially rewarded by each.

As early as 1843 the telegraph was made use of by the police on Ascot race days, by the detectives at Paddington Station making known to their brother officers at Slough Station the movements of well-known bad characters of thievish propensities, who, on receiving a friendly warning on arrival at Slough Station, thought it unwise to put in an appearance at the racecourse, and either loitered about Slough or took an early return train.

The next telegram in importance to that relative to the birth of H.R.H. the Duke of Edinburgh was that which was sent me at Paddington respecting the Salt Hill tragedy, and which enabled me to have the Great Western Railway Company's sergeant of police (Williams) in readiness on the arrival at Paddington of the 8.25 p.m. train, and to whom I introduced, or rather pointed out, the chief actor in that very remarkable tragedy, the closing act in which a gentleman named Calcraft was requested to take a prominent part at Aylesbury on March 14, 1845. A more striking illustration of the value of the telegraph could not possibly be considered. Williams was in private clothes, so no suspicion was aroused, and it was arranged that he should act as conductor to the bus, which post he kept until it arrived in the City, when the man he was specially assigned to watch left the bus, and was followed by Williams to the Jerusalem coffee house, where, learning all particulars as to name and address of the suspected party, he left him for the night. Williams's instructions did not go further than this, as the man's apparent respectability created a kind of doubt as to his guilt. Even the deputy superintendent at Paddington (Mr. De May) remarked to Williams and myself, when I opened the first class carriage in which the man rode to Paddington, that "it was all a mare's nest," an opinion, however, which neither the jury at Salt Hill nor the one at Aylesbury thought fit to endorse.

On entering the telegraph office the following morning I received instructions to send Williams to apprehend the man whom he found at the said coffee house."

THE EFFICIENCY OF SMALL ELECTRO-MOTORS.*

BY E. H. CLIFFORD.

The author gives the results of tests made at the Massachusetts Institute of Technology, by Messrs. F. A. Pickernell, H. G. Pratt, D. P. Bartlett, and himself. The experiments were exclusively devoted to the determination of efficiencies; governing and smoothness of running under different loads being disregarded. The instruments used in the determination of the current and electromotive force were Sir William Thomson's current and potential galvanometers. These had previously been carefully calibrated, and found to be correct to within 0·2 per cent. in the positions in which they were used in the tests. In cases where the compensating magnets had to be used, their intensity was carefully determined on each day of use; as far as possible, however, the use of the magnets was avoided. For measuring the power given out by the smaller motors, a raw-hide belt or a cotton cord was passed completely round a brass pulley on the motor-shaft, the upper end being attached to a spring-balance, and the lower end to a scale-pan. By varying the weight in the scale-pan, the speed of the motor could be changed. A Chatillon balance, weighing to ⅛oz., was

* Abstract of paper from *Proceedings* of the American Academy of Arts and Sciences, given in the *Journal* of the Institution of Civil Engineers.

used. In the tests on the Gramme magneto and the Gramme "small light," the machines were placed in a cradle dynamometer, a modification of the form devised by Prof. Brackett, of Princetown, and a dynamo machine was used as a friction-brake. By closing the circuit of the dynamo through greater or less resistance, the work done, and consequently the power absorbed by the brake, could be varied. For accurately measuring the speed, the speed-indicator from a small siren was used. This was connected to the motor by an endless band, passing from the pulley on the motor shaft to a pulley of the same diameter as the siren. The power required to run this indicator was extremely small, and, in computing the work done, was not considered. The slip of the belt was negligible, as shown by numerous tests. With the Gramme magneto and the Gramme small-light, a continuously-recording engine-counter was used, connected to the motor by means of a flexible spiral spring.

Thirteen motors were tested, a short description, or reference to a published account, of each of which is given by the author.

The author's Table II. gives full details of the tests of the model Edison machine. The motors tested were, with one exception—the Gramme small-light machine—intended for very light work, and the efficiencies were therefore not nearly so high as would be shown with larger machines. In a paper on "Electromotors and their Government,"† Profs. Ayrton and Perry state that motors may be constructed to deliver 1 h.-p. per 100lb. of dead weight. Table III. does not support this conclusion; and the author thinks that, for moderately small motors, 300lb. per h.-p. would be a closer figure, although with larger motors this would be considerably reduced.

TABLE I.

Name of Motor.	C.	E.M.F.	H.P.	Max'm Effi'ncy.	Speed.
	Amperes	Volts at Motor Term'ls.		Per cent.	Revol'ns per Minute.
Griscom	3·94	6·74	0·006	17·0	1,400
Ayrton and Perry	14·40	11·10	0·082	38·4	831
Gramme "Small Light"	5·29	157·60	0·945	84·5	2,227
Gramme Magneto	12·60	27·40	0·138	29·8	2,067
Thompson	4·90	8·50	0·012	21·7	2,370
Deprez	4·74	10·40	0·011	16·6	2,140
Monarch	4·85	5·78	0·004	10·1	578
Cleveland	6·78	12·00	0 054	49·8	1,360
Model Edison	0·82	90·50	0·051	51·4	4,065
Diehl 1	7·65	16.50	0·021	12·3	4,180
Diehl 2	6·12	15·10	0·031	24·9	2,480
Hill 1	4·77	10·30	0·010	14·8	2,036
Hill 2	5·04	15·10	0·032	31·6	3,030

TABLE III.

Name of Motor.	Weight in Pounds.	Maximum H.P. Delivered.	H.P. per Pound W'ght.
Griscom	2·80	0·0202	0·0072
Ayrton and Perry	39·00	0·1738	0·0045
Gramme Small Light	172·00	1·3160	0·0077
Gramme Magneto	70·00	0·1512	0·0022
Thompson	6·30	0·0138	0 0022
Deprez	9·60	0·0138	0·0015
Monarch	6·10	0 0041	0·0007
Cleveland	18·50	0·1290	0·0032
Model Edison	15·25	0·0544	0·0036
Diehl 1	9·50	0·0209	0·0022
Diehl 2	20·00	0·0309	0·0015
Hill 1	7·00	0·0120	0·0017
Hill 2	16·00	0·0374	0·0023

† *Journal* of the Society of Telegraph-Engineers. 1883, p. 301.

LITERATURE.

On a Surf-Bound Coast, or Cable-laying in the African Tropics. By ARCHER P. CROUCH, B.A. [Sampson Low, Marston and Co.]

We have read this book from beginning to end with a great deal of pleasure. It certainly possesses the great merit of "go" and liveliness, and in common with the needy knife-grinder, "story it has none." The book is what it purports to be, a "portion of a diary written during a cable-laying expedition." The expedition was that of the Silvertown Company to lay a portion of the West Coast of Africa cables, and we may go further than this book does, in stating that the expedition was perfectly successful. Not only did it do good work in laying cables, but the expedition added extensively to our knowledge of the ocean bed through the numerous soundings that were taken over the course in which the cables were laid.

This, the newest book about cable-laying, caused us to look out and con over once more the first descriptive book on the subject, that of Dr. W. H. Russell, published just over twenty years ago, in which the concluding sentence reads: "The last word transmitted through the old telegraph from Europe to America was 'Forward,' and 'Forward' is the motto of the enterprise still." From then till now the cry has been "Forward," till the Alexanders of the cable world have joined together the uttermost parts of the earth. They may have no new worlds to conquer, but their work is far from complete. Feeding links to the main cables will be needed in every direction, and cable-laying and cable-repairing will long be a field for the dis play of science, experience and skill. Mr. Crouch's book does not pretend to be scientific, in fact that part of the business is carefully eschewed; but it is a graphic, racy sketch of the life led during a cable-laying expedition. It touches with a light, but firm hand, the life on board ship, both while waiting and while active; it describes briefly but clearly the broad peculiarities of the places touched at, and keeps up from first to last a good substratum of fun at all the surroundings, and especially the *genus homo.* Those who have had a peep behind the scenes will have no difficulty in fitting the characters of the book to individuals, although the *noms de plume* used give no clue to outsiders. As a specimen of the author's manner and lighter matter, we may quote the following, wherein Mr. Jenkins describes his first night at Accra. Mr. Jenkins was directed to the house of a Mr. Schwortz, at which in due course he arrives, coolly walks in, takes the easy chair, and commences a pipe. By-and-bye he is discovered by a servant, who rushes off and brings back Mr. Schwortz, who cries out:—

"'Who are you? What do you want? What business have you got here? Just clear out of my house!' To which I replied, not quite liking his manner, with considerable deliberation and interspersed with several puffs at my pipe—

"'I am afraid there is some little misunderstanding here. My name is Jenkins. You I believe to be Mr. Schwortz; and I was told that you had kindly offered to put me up for the night.'

"'My name is Schwortz, but I never heard of yours before; so the sooner you move out of my house the better.'

"Well, this treatment kind of roused me. It wasn't hospitable, to say the least, considering it was my first night ashore. So I said—

"'Mr. Schwortz, I reckon you must be labouring under some mistake. Your name was given me, this house was pointed out to me, I was told to come here, and here I am, and here I mean to stay.'

"'But I don't know you, I tell you.'

"'Well, if it comes to that,' I replied, 'I don't know you either. So we're level there.'

"He looked at me gasping for a minute or two, and then he pulled himself together and began stamping up and down the room kicking at all the tables and chairs which lay in his way.

"'This is a nice state of things! You come in here, light a pipe, seat yourself on my favourite easy chair, and positively refuse to move when so requested. You'll be ordering dinner next, I suppose. Is there anything I can fetch you?' he adds in a tone of mock servility.

"'Well now, since you mention it, I should like a bottle of lager.'

"Whether he felt himself wholly unequal to contend any longer against the course things were taking, or whether the mention of a favourite drink was sufficient to dispel his anger, I couldn't say; but the expression of his countenance changed and broke into a radiant smile, and turning to the nigger who was standing in the door-way, he cries—

"'Hie, you rascal, go and bring a couple of bottles of lager;' and then he placed before me a box of cigars, and sitting down, he made himself so agreeable that I don't know if I have ever been better lodged in foreign parts than I was last night."

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

INTERFERENCE OR COMPETITION.

The action of the Maxim-Weston Company in connection with the recent negotiations concerning the lighting of the City with the electric light has been commented on with considerable asperity and severity. The time has come when the question may be asked if such action can be justified in any shape or form by the laws which usually govern business transactions. Competition may be fair or unfair. It may be keen and sharp, yet perfectly legitimate; while, on the other hand, some methods of procedure are disclaimed by all whose ambition is to be reckoned amongst those deemed honest men. It is said that most of us start out in the world with the object of making money, to make it honestly if we can, but to make money. These words, which are so frequently heard, show that two ways of making money are recognised, one of which is by no means satisfactory. There is one way of making money that has received little attention, and which depends chiefly upon the way in which other people's money is lost. Directors of public companies are sometimes in the peculiar position of being able to make money at the expense of the shareholders. In fact there are four results which their efforts may bring about. They may benefit both themselves and the shareholders, themselves and not the shareholders, the shareholders and not themselves, or neither themselves nor the shareholders. As a rule, directors are firm believers in the policy of one of England's greatest premiers, whose greatest anxiety was always for the welfare of the greatest number, but who admitted, on being cross-questioned upon the subject that the greatest number was—Number one. A paraphrase upon the above words might be given, that it is the duty of every firm to get business, honestly if it can, but at any rate to get business. Here it seems we have the kernel of fair and unfair competition, the latter coming from those whose sole object is—at any rate to get business.

An earnest faith that, somehow, whatever is done will turn out well, and an intensely real conviction of the transcendental force of their own business capacity are the characteristics of the men whose sole object in life is to get business and to make money. They idolise the American system, wherein no moral law is tolerated, nor by which is anything permitted to stand in the way of attaining the object aimed at. We cannot say of those men what Froude says of England's forgotten worthies, "their profession was the school of their nature, a high moral education which most brought out what was most nobly human in them;" but rather we would say of them as Artemus Ward said, "There is much human natur in man."

There are two fundamental ways and two only for obtaining business; the one where the purchaser experiences a want, and of his own accord goes to

supply it; the other, and the more frequent, where the supplier has to prove to the purchaser that this want really exists. The man who has always been blind cannot of himself experience the want of "more light," nor can he who has never had the sensation of taste want "more sweetness." Others may, however, explain to the blind the advantages of light, and hence get him to experience the want, and likewise with taste. The business man, so to speak, has to open the eyes of the blind and the ears of the deaf in order to obtain custom.

Consider then the special case we have mentioned, though it is by no means the only one of its kind. The Corporation has a faint notion that there exists a want of more light, and that it can be supplied by electricity; but it required the consistent and persistent efforts of the Brush Company, extended over a couple of years, to thoroughly convince a committee of the reality for the want and ability of that company satisfactorily to supply it. So far, however, success has attended the Company. History records the lighting failures in the city, and unwritten history tells the reason of these failures. It is agreed among competent men that there is no valid reason why the Brush Company should not have successfully carried out the contract on the lines submitted to the Corporation. It is well known that the plans had been carefully matured, the details examined and re-examined, and that so far as the experience and scientific attainments of the Company's staff could suggest, they were perfectly well adapted for the purpose in view.

At the eleventh hour, the Maxim-Weston Company comes forward with a crude ill-considered scheme, and offers to perform certain work for a certain sum. Now we most distinctly, deliberately and emphatically, say that the proposed work could not be carried out for the sums which have been publicly mentioned; and we call upon the Maxim-Weston Company to justify its action by producing the detailed estimates upon which the tender was based. If the amount of the tender was so low that the work would result in a loss and not a profit—and if this was known in any shape or form to the directors—we say that they acted in a most unfair and unbusiness like manner, not only to their trade competitors but also to their shareholders. If the directors have been misled by miscalculations of their servants the sooner they acknowledge the fact the better. There is no doubt but that the damage done by the mis-timed action to the immediate progress of the industry has been very great; and if such actions are to be connived at without general condemnation the sooner that fact is known the better. Is it fair competition to wait till an opponents scheme and price are practically public before making an offer for the work? We will not say a word as to the possibility of the Maxim-Weston Company being able to carry out the scheme proposed. Let it be assumed that no hindrances, financial or otherwise, would have been met; the question still remains whether it was fair competition to utilize obstructively another company's initiative and labour. If both schemes had been put forward together, and driven side by side, there would have been nothing to say; but it was not so, the one was not heard of till the other was practically settled. We maintain that the action of the Maxim-Weston must be repudiated by every honest trader in the country, till such time that they can show that they were called upon to formulate a scheme and to submit a tender, and prove incorrect our contention that the work proposed could not be carried to success for the amount specified in the tender.

THE PRESENT STATE OF FIRE TELEGRAPHY.

The paper read by G. R. von Fischer Truenfeld on this subject at the last meeting of the Society of Telegraph Engineers is an interesting one from several points of view. The subject is one that has been but little studied. Unfortunately the demands upon our space preclude any possibility of giving the paper fully, so that we must content ourselves with giving the conclusions of the author as deduced from the mass of statistical information examined by him. There is only one point in this paper whereon our opinions differ materially from those of the author. But first we give the author's summary as follows:—

I will now recapitulate the facts which result from the numerous official reports laid before you, viz.:—

1. Since the subject of fire-telegraphy was first publicly introduced before this Society in 1877, a great general progress has been made in British towns and elsewhere in the increase of facilities for raising speedy alarms at the outbreak of fires. The time between the discovery of a fire and the appearance of the brigade has thus been considerably reduced.

2. Fire-telegraph street call-points were first introduced in London in the year 1880. They not only proved to be of great value in reducing serious fires, and thus saving property, but it also soon became evident that the fear of wilful damage to the fire-telegraphs and of false alarms being raised is not so well founded as to detract from the high value of a complete fire-telegraph installation.

3. Not only has the number of alarm points been generally increased, but a limited number of British towns has already successfully adopted a system of public call-points.

4. Although a general increase of population and a consequent increase in the number of fires has everywhere taken place, the percentage of serious fires, and with it the amount of property destroyed, has, nevertheless, been generally decreased. This has been the consequence not only of a greater efficiency of the brigades, but especially of the higher proportion of alarm-points to inhabitants, which, again, is identical with ampler provision of telegraphic appliances and with more rapid telegraphic communication.

5. Although the number of alarm-points has generally increased in British towns, and the percentage of serious fires has accordingly diminished, these undoubted improvements have, nevertheless, not yet reached that point of perfection which they ought to attain. Both the proportion between alarm-points and inhabitants and the percentage of serious fires in British towns compare badly with Con-

tinental and American towns. Whereas in the former an average number of 27,000 inhabitants counts for each fire-alarm point, only about 3,000 inhabitants corresponds to every alarm-point in Continental towns, and even less in America.

6. As serious fires have become proportionately less, the total loss of property has not increased during the last ten years, although the total number of fires has nearly doubled. The present average loss of property for each fire is thus only about half, and often even less than half, the amount it was ten years ago.

7. The percentage of lives lost from fires has not been appreciably influenced by an increase of alarm-points. In spite of the increased efficiency of brigades and of more extended telegraphs, modern fires show a more destructive tendency, so that an increase in the percentage of lives lost is apparent not only in England, but generally. As the protection of life chiefly depends upon factors which lie very much beyond the reach of even the most efficient brigade and the most perfect telegraph equipment, the latter can only contribute in preventing a more rapid increase in the death-roll from fires.

8. The inhabitants of all towns which have adopted fire-telegraphs soon became used to the electrical appliances. Thus by far the greater number of fire alarms have been transmitted by street call-points and other electrical appliances, and only a very small proportion have been received verbally.

9. Considerable advantages accrue to any fire-telegraph system, and consequently to the protection of property, from the connection of such system with that of the Telephone Exchange.

From the general tone of the paper—as well as conclusion 7—we gather that Mr. Truenfeld was surprised to find the percentage death rate undiminished by the increased use of better appliances. We on the contrary should have been just as surprised to find the percentage death loss diminished. It seems to us that the use of better appliances is calculated—as was proved by the author—to lessen the average money loss per fire, and that is a great achievement. As a matter of fact, we believe, the majority of deaths are caused by suffocation, and probably, in the greater number of instances where loss of life occurs, the death takes place before the existence of the fire is known. Of course we must except from this statement fires in theatres, although again the death is here due to suffocation; but in this case the disaster is usually due to a total disregard of all provision for emptying the theatre quickly. If our contention is right, the death rate will always be proportional to the number of fires and not to the magnitude of the fires.

CORRESPONDENCE.

TRANSFORMERS.

To the Editor of the Electrical Engineer.

Sir: I had more than one reason in not giving full figures in support of my argument in favour of "transforming by means of accumulators," at the recent meeting of the Society of Telegraph Engineers.

1st. I had already written, at the request of my friend, Mr. Kapp, a memorandum for his paper, and I did not consider myself justified in using the same figures pending the publication of that statement.

2nd. I prefer to bring these figures forward in a paper of my own, where I should have the right of rejoinder
after they have been thoroughly criticised by others.
are, perhaps, aware that I intend to deal with the su
in a paper I am to read before the Society of Arts in
and I trust that the council of the Society of Teleg
Engineers will be able to find room for a short paper o
same subject during the present session, so that ever
interested in the subject will have ample opportuni
criticising my figures, and forming his judgment the
—Yours, &c., R. E. Crompto

Mansion House-buildings, London, E.C., March 12, 1

FIRE OFFICE RULES.

To the Editor of The Electrical Engineer.

Sir: At length the blow has fallen, and we have
another set of Fire Insurance rules!

We have to-day seen a copy, and we presume that
not only will the telegraph engineers get out a set,
every individual insurance company will follow. Wha
contractors to do then; what will the public think? S
if the society had only been content to adopt the
known Phœnix rules, and embody them as their ow
course acknowledging their origin), all this trouble m
have been averted.

Who can tell the amount of damage that will be do
our industry through the obstinate and irresponsible a
of our presumably representative society?

If a poll had been taken of the society's members,
the electrical trade, would not the verdict have bee
favour of letting well alone, and giving to the Ph
rules (which certainly have the merit not only of pric
but of secured success) the authority of the tr
society?

These are burning questions, and certainly require
immediate attention of every

Electrical Contracto

ELECTRIC MOTORS.*

BY G. A. LEIBIG, JUN.

The development of the electric motor from its primitive
up to its present state of advancement and usefulness has
similar to the growth of nearly all of those great discov
which have proved themselves at first so adaptable and the
necessary to the wants of everyday life.

The history of the motor is a very remarkable one, not
as a story of rapid improvement, but also because its first
ters belong to very recent times.

We can now ask ourselves, not without astonishment, w
happened, seeing that the laws of the conservation of en
were so generally accepted that the reversibility of the dy
and motor was so lately discovered. It is quite true tha
first motor was built many years ago, but for a long time,
after the dynamo had undergone many marked improvem
the motor was not turned to practical account. In other w
dynamos and motors have all along been kept distinctly a
and even to-day there exists sometimes a certain indefinit
about their relation.

We now know that the general term "Dynamo Ele
Machine" includes not only generators of electricity but
appliances for converting electricity into other forms of en
and that all the mathematical formulæ which have been ap
to the dynamo as a generator of electricity are equally appli
to the dynamo when viewed as a source of motive power,
only changes necessary in any formulæ relate to the alge
signs of certain symbols.

The feature of reversibility is of extreme importance,
means that any rule of construction or of design that ten
make a dynamo machine an efficient apparatus will give ide
results when used in connection with motors. Other consi
tions may present themselves, questions of speed and outpu
unit weight of material may arise, and these may be differe
the two cases, but they are of a mechanical, or at any
secondary interest, and in no way affect the mathematical
siderations. In what follows, therefore, we shall use the
"dynamo electric machine" to designate, unless othe
specified, either a generator of electricity or a dynamo reve
i.e., a motor.

In order to give an intelligible review of the work whic
been done on dynamos and prepare the way for a few consi
tions which will follow, it may be well to describe briefly

* Paper read before the National Electric Light Association,
burgh, Feb. 21-23.

component parts of a dynamo electric machine, and refer to the purposes for which they are intended. In every dynamo we must have a continuation of the following elements :—

(*a*.) An iron body or framework constituting the magnetic limbs. This is always wrapped over a certain portion of its length with insulated copper wire, and its purpose is to produce between its ends or polar surfaces a region of magnetic force.

(*b*.) A series of coils of copper wire, generally wound upon a subdivided mass of iron, and capable of revolution about an axis in such a way as to make each coil pass successively before the polar surfaces of the magnetic limbs. This is called the armature, and is always so placed that it helps with the magnets to form a nearly closed magnetic circuit of iron.

(*c*.) A commutator, which is merely the projected ends of the armature coils, and which, revolving with the armature, effects a continuance in the direction of the currents formed alternately plus and minus.

(*d*.) Several brushes or collectors, usually two in number, consisting of pieces of metal which press upon the segments of the commutator, and which are in metallic communication with the terminals of the machine.

In general, the armatures revolve between the poles of the electro-magnets, but in some machines, notably those intended to furnish alternate currents, the armature is stationary and the magnet coils themselves revolve. This is, however, immaterial, inasmuch as what we have to consider is the relative motion of the parts of the machine, not their absolute movements.

It appears, therefore, that the dynamo machine, since it consists, broadly speaking, of an electro-magnet and a revolving coil of wire is a very simple piece of machinery, yet it has taken years of hard labour and patient investigation to evolve from the spinning disk of Faraday the dynamo of to-day. There is a feature in the history of the dynamo which must appear remarkable to everyone thinking of the subject. When we remember how much attention has been directed to dynamo machines, not only by practical but also by scientific men, and recollect that all the materials for a complete theory of the dynamo have been for several years at hand, we are inclined to wonder at the absence of such a theory. Even to-day no complete theory exists, though we are in an immeasurably better position in this respect than we were five years ago. For what we now know, in so far as it is immediately applicable to dynamos, we are mainly indebted to the labours of Clausius, Hopkinson, and a few others. It is sometimes claimed that the theory of the dynamo has been seriously crippled by the want of sufficient knowledge regarding the law of electro-magnets, namely, the law connecting magnetic force with the magnetism thereby produced in magnetic bodies. If we admit that an empirical formula is required we must admit the justice of the claim, because no accurate expression of this kind has ever been originated. But we shall see that is by no means necessary to depend upon empirical laws ; all that we require are the causes of magnetisation, and these have been before the world for some years. However, we now possess the results of a new series of investigations on magnetisation and magnetism and magnetic permeability undertaken at home and abroad, among which the most important are those of Hopkinson, Ewing, Rowland, Waibing, &c. These results, in connection with the work already referred to, make it possible to calculate to a close approximation—at least for certain forms of machines—just what any given dynamo will do when we know, besides its dimensions and configurations, the kind of iron used in its manufacture.

The word magnetic permeability, used above and which enters so frequently into dynamo calculations, is defined by Maxwell (Vol. 2, p. 50) as the ratio of magnetic induction to magnetic force. It is also called magnetic inductive capacity, corresponding with specific inductive capacity in electro-statics. Following out an analogy in a different direction, it sometimes happens that magnetic permeability is called magnetic conductivity, or resistance, the idea being to express the varying resistance offered by a given body to the production within it of "lines of induction," just as the lines of flow are opposed by a porous solid, through which is forced an incompressible liquid. Further, we know (Maxwell, Vol. 2, p. 51) that the magnetic induction is related to the magnetic force in exactly the same way that current is related to electromotive force, namely, we have :

$$B = u\,H \text{ and } C = R\,E,$$

when u is the permeability, and R the conductivity. But the analogy is in a sense imperfect, for whereas R (conductivity) is a constant, in so far, at least, as it is absolutely independent of the current flowing (leaving all heating effects out of consideration), the permeability is by no means a constant, but depends not only upon the present state of the material in reference to the induction within it, but also upon its previous "magnetic history." Thus it is a variable quantity, and, for magnetic bodies, grows less and less as the magnetising force increases. We can, therefore, regard the analogy between B and H on the one hand, and C and E on the other, as holding good only when H is a very small quantity.

In the calculations applied to dynamos it is extremely important to know the distribution of magnetism and the polar surfaces of the electro-magnets ; that is, the number and direction of the lines of induction from pole to pole. A solution of this problem can be arrived at mathematically in an approximate way only, and then, as a rule, by the consideration of what takes place in the least complex forms of surfaces. To attain certain ends the graphic method may be applied either roughly by the use of iron filings or more carefully by the employment of a small magnet suspended by a film. By observing the positions assumed by this small magnet, when fully suspended in different regions of the magnetic field, we can form some idea of the form of the field. For we know that the direction given by the magnet coincides with the resultant direction of the magnetic force at that point (the needle being supposed so small as to exert no disturbing influence), and also that the relative number of lines of force in a small space surrounding the point measures the relative field intensity. The positive directions of the lines of force may be taken as from the north pole to the south pole, both outside and inside the magnet, and they are related to lines of induction in this way : Outside the magnet they coincide, inside the magnet they are in opposite directions. This amounts to saying that the lines of induction are continuous, whereas the lines of force are not.

Other methods of measuring the field intensity of dynamos have been proposed, such as the magnetometric method. The results so obtained are, however, inaccurate ; and, indeed, the method cannot be applied at all when the armature is in place. Nor can the very simple pendulum method devised by Sir Wm. Thomson be applied, because the air space between the armature and magnets is too small. It can, of course, be used by removing the armature, and it has the advantage of giving results directly in absolute measure. Unfortunately measurements obtained under these circumstances do not give us a reliable basis for calculations, inasmuch as the form of the magnetic field is strongly influenced by the presence or absence of the armature, at least when it contains iron. It may be remarked that magnetic distribution is exactly analogous to electric distribution, especially in the case of dielectrics, and that the geometric form which influences the latter plays almost as important a part in the case of magnetic distribution.

We are well aware that the density of electricity in a given portion of a charged body depends upon the shape of the body, and also upon the presence near it of other charged bodies. The same laws of surface densities determining the so-called leakage of lines of force obtain in the case of magnetism. In almost all dynamos the pole pieces have necessarily somewhat sharp edges, and the number of lines of force per unit area is greater at the edges than on the remaining polar surface. This number is subject to a change when the armature is in place, and to a further modification when the armature revolves, on account of the changes in the direction of the axis of magnetisation of the latter.

These considerations show us that any system of measurement which will give useful results must be of such a nature as to be applicable to the dynamo when in working order. The ballistic method fulfils these requirements, it is sufficiently accurate, and, moreover, involves no special difficulty. We have simply to surround that part of the magnetic circuit of which we want the induction, with one or more turns of copper wire connected with the ballistic galvanometer, and observe the throw of the galvanometer needle when the magnetism is reversed or reduced to zero. It is always better to observe the deflection of the galvanometer needle due to a reversal of magnetism. An uncertainty always attends a reduction to zero, owing to the phenomenon of residual magnetism. The galvanometer having once been calibrated in absolute measure, we can, from the throw of the needle, calculate the value of the total induction within the wire, and the magnetic force is known from the data of magnetising current and number of revolutions. The experiment is repeated for the different parts of the machine, so that we finally obtain the values of the induction throughout the entire magnetic circuit. Suppose, now, we have measured the field intensity, and have a value of the induction per unit area, we can then, by Faraday's law, calculate the electromotive force which would be set up in a conductor moving in any manner in the field. The law is this : The E.M.F. produced in a conductor moving in a magnetic field is equal to the rate of cutting the lines of force. If the conductor forms a closed circuit, the E.M.F. depends upon the area of the circuit. Hence, in order to be able to determine the E.M.F. produced in an armature, we must know the mean area of the coils of the armature, the strength of the magnetic field, and the velocity of rotation.

Call N the total number of lines of induction (flow of force) passing through the armature, and p the current ; then we have for the force X acting when the circuit is displaced through the distance $d\,x$, by the principle of the conservation of energy (Maxwell, vol. 2, p. 137) :

$$X = -p\,\frac{d\,N}{d\,x}.$$

I. Heating of wires equal to

$$C^2 R \quad \text{or} \quad E^2/R.$$

II. Foucault currents in pole-pieces. This depends upon number of armature section (*i.e.*, fluctuations of current), and is generally small, unless the Pacinotti form of armature is used.

III. Foucault currents in armature. This depends upon (strength of field)^2 and in the modern laminated armature may be neglected.

IV. Reversals of magnetism of armature equal to $\frac{1}{4} \pm$ Casicine force × maximum induction × n × volume.

That is, it depends upon (strength of field)^2 and velocity of rotation. No amount of subdivision of armature coil can affect this except in so far as it modifies the total volume of iron in the armature. However, a low magnetic resistance is necessary, and to secure this the armature must contain much iron. It is on this account that an advantage from a stationary armature coil would be derived.

V. Momentary short-circuiting of armature coils, depending upon caef of coef and mutual induction of armature coils and strength of field.

VI. Finally: Friction in bearings. This is difficult to estimate. If the belt is such that Main's principle holds true, losses due to friction are constant.

In regulating motors the speed is constant, or nearly so, hence the causes of the dissipation of energy are confined to variable currents in the conductors and to changing field strength. These in compound wound and constant current motors depend upon the load, but as we see at once are practically constant for a properly-made shunt machine. For a pure shunt machine, therefore, the efficiency, provided the speed does not change, is independent of the load.

Before bringing to a close the few remarks which I have ventured to make on the subject of electric motors, it may be interesting to give a few facts regarding the growth of the motor industry, and point out how various are the demands made upon the machines for manufacturing and commercial purposes.

Through the kindness of the Executive Committee of the National Electric Light Association I am enabled to bring before you a few figures, which will, I trust, act as an incentive to increased activity in this direction.

The committee has addressed circulars to 234 companies engaged in electric lighting, with the following questions :—

I. Number of motors in operation.
II. Size of motor.
III. Maker's name.
IV. Currrent used.
V. Charge per h.-p. per month.
VI. Charge per month per arc and incandescent lamp.
VII. Results as to service.
VIII. Consumers' opinions as to power and service.

As a result, answers have been received from fifty-six companies, and from these replies the following statements have been gathered :—

Average charge per h.-p. per month, 10 hours' run...	$10.00
Average charge incandescent lamp, 10 hours' run ...	13.50
Average charge per arc lamp till 10 o'clock	9.83
Average charge per arc lamp until 12 p.m.	13.00
Average charge per arc lamp all night	22.00
Highest charge per h.-p. per month	15.00
Lowest charge per h.-p. per month	6.25
Highest charge per incandescent lamp per h.p.	21.00
Lowest charge per incandescent lamp per h.-p.	11.25

The motors supplied with current have been used for the following purposes: Driving ventilator fans, collar and cuff machines, printing presses, various apparatus in repair shops, sewing machines, coffee mills, machines in gun shops, sausage machines, elevators, lathes, pumps, saws, ice-cream freezers, organ bellows, appliances in laundries, &c.

Sizes of motors have varied from $\frac{1}{8}$ to 15 h.-p. Twenty-six companies have supplied motors from arc light circuits, 14 from arc and incandescent, and 16 from incandescent lamp circuits alone.

In 34 cases subscribers own motors and pay per month for current; in other cases companies own motors and charge rental for same. Companies are endeavouring to have subscriber's own motor in all cases and pay for current. Electric light companies are satisfied and willing to enlarge the business. Consumers reports are also very satisfactory.

Although the number of cases cited above is small, it is still enough to show us how effectually the motor can supplant the steam-engine, especially for those purposes for which the power required is small and under complete control. The opinion of those who have used electric motors indicated that they do their work well, and encourages us to expect a brilliant future for this branch of applied electricity.

ALTERNATING CURRENT ELECTRIC MOTORS.

BY DR. LOUIS DUNCAN.

(Concluded from page 233.)

What seems to me the simplest, cheapest, and most efficient means of running alternating current motors is this: build the motor on the same general plan as the dynamo, with such modifications as the different conditions of working impose, and start it and excite the field magnets from a continuous current circuit, run with our alternating circuit, supplied with current by a dynamo at the central station. If we wish to distribute 500 horse-power our continuous circuit should have a maximum capacity of about 50 horse-power. To start the motor we should have the following arrangement: there should be two breaks in our armature circuit, one between the regular brushes of the machine, the other at a commutator for the continuous current. At this second break the two ends of the circuit should be taken to alternate bars of the commutator, the number of bars being such that the direction of the current is reversed every time a coil passes a pole. The alternate bars are normally connected by a metal ring pressed against them by a spring; in this case we will have the normal circuit just as if there were no continuous current commutator. On the motor would be a switch-board that would accomplish the following things: If we wish to start we turn the handle of the switch to a certain position, this will short circuit our regular brushes and by the aid of a couple of levers will drop the continuous circuit brushes on the commutator, at the same time pulling away our metal ring. The motor will then start as a continuous current motor; when it has reached its proper number of revolutions or is above it, turn the handle a little further; the continuous current brushes will be raised, the metal ring will connect the commutator bars, and the alternating circuit will be made, and the motor will continue to run and will do work.

Now, I consider that the advantages of this plan are these: It makes the motor simple and cheap to build; it will be more efficient and have a greater output than the other motors that have been discussed; the currents to excite the fields will have to be supplied anyhow, and they cannot be supplied more economically than from the central station: being simpler there will be less liability of derangement.

The motor described by Professor Thomson that I mentioned above, consists of field magnets, through which the alternating current flows, with an armature not in any way connected with the external source of current, but which has currents induced in it just as if it were the secondary of a transformer. The circuits of all the armature coils are open, excepting one that is in such a position that the current induced in it will be repelled by the pole-pieces. In this form I do not think the motor will be particularly efficient, or give any considerable output. It is possible that the principle may be further developed to give a considerable output, but I do not believe that any motor in which the field is fed by alternating currents can be cheaply made, although this is a matter of which I have no experience.

To prevent motors stopping when the load is thrown on it would only be necessary to drive the load from a friction pulley on the shaft of the motor. The pulley should be so adjusted that it will turn just before the motor falls behind its point of its maximum work.

It is possible that all of the plans I have suggested have been tried by the different inventors who are at work on this subject. If a motor of each type that I have mentioned were built, and proper experiments were tried upon them, we would—provided we had the ability to interpret and apply our results—have the data necessary to design the best possible machine of each type, and if we build these it would settle the question as to which form will be the best. There is no necessity in building an indefinite number of motors to experiment with. It is too much the custom, if we wish to design a dynamo, for instance, to build twenty different ones and see which is best. One machine, with proper experiments and deductions, should put us on the right track.

Dr. Holmes once said that when he had written anything that pleased him it immediately seemed very old indeed. I, with humility, feel much the same way, as if what I had said this evening is so apparent that every one must have known it. I can only hope that some of the suggestions I have made will help the development and final successful application of the alternating current motor.

DISCUSSION.

Mr. Wolcott: I have been very much interested in Professor Duncan's paper. It throws rather a different light upon the subject of alternating motors from the paper of Mr. Stanley. From the latter paper we concluded that the alternating system, all the way through, was slightly more economical than the direct. But Professor Duncan has shown, I think, pretty conclusively that there are various losses there which we do not have in the direct system. The loss from heat, which depends upon the square of the current, I think is very neatly demonstrated: the work depending on the product of the current and the electromotive force changing in sign whenever the

electromotive force changes, while the loss in heat is constantly plus because the square of the minus quantity is plus, as well as that of of the plus quantity. There is one advantage, I think, in the alternating system which is entirely of a practical nature, irrespective of the efficiency, and that is that you do not use any commutator at all. I know one of the greatest practical difficulties in both motors and dynamos is the trouble of having a commutator. If there is any possibility of running a street railway with an alternating motor I think it would be a great advantage, even if it was not so economical.

Mr. Mailloux: I would like to remark with reference to the application of alternating currents to the purposes of electrical traction, as my friend Mr. Wolcott suggests, that it will probably be some time before we succeed in utilising it, however great may be the advantage of its use; because the alternating current motor fails to afford one of the chief requirements demanded in a motor for electrical traction,

FIG. 9.

namely, capacity for producing great torque or effort at the periphery of the armature at the time of starting. This is exactly what the alternating current will not do. Dr. Duncan has pointed out the necessity for gradually putting the load on, so to speak; while, as we know, in electrical traction, it is necessary to develop large pulling capacity or effort.

Mr. Crocker: There are two or three practical points that suggest themselves to me. In the first place, Dr. Duncan speaks about the great cost of a laminated field, and he speaks of it as if it were practically a bar to the use of laminated fields. If I were going to make a wrought iron field, or if I were bidding for a contract to make wrought iron fields, I would prefer to make them laminated rather than of forging or any other form of wrought iron that I have ever come across. So far as I am concerned, I prefer the laminations. I have been experimenting somewhat myself in this direction and was quite pleased with that feature of the alternating current motors, viz., that they *did* involve laminated fields. Then the other point, about putting on of a load suddenly. That is a difficulty no doubt, and a serious one; but still it does not go on with the mathematical suddenness that Dr. Duncan speaks of, I think. The belt will squeak and the load will gradually come on, and in ordinary cases, where the load is great, but not very great, it will come on gradually, the motor will take it and, I think, will run along with it. Of course, that is a question of degree; in some cases it would, in some cases it would not. But I think you could arrange that by avoiding the introduction of alternating current

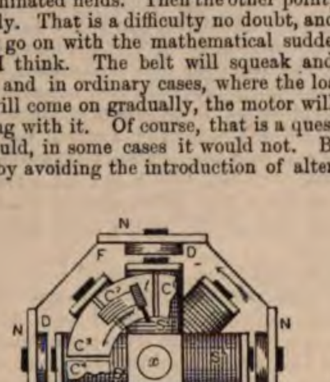


FIG. 10.

motors where they had to suddenly take a heavy load, and that would be, of course, a limitation. Then as to the objection that Mr. Mailloux brought up, he spoke merely of one particular kind of alternating current motor, whereas Dr. Duncan enumerated four. I do not remember the classification very well, but I think Mr. Mailloux's objection only applies to one or two of the four classifications. The other two would be entirely outside of Mr. Mailloux's objection.

Lieut. F. J. Patten: Dr. Duncan has shown us that the curve of counter-electromotive force has a variable position with respect to the mean, *i.e.*, oscillating from side to side; and I wish to ask whether any such oscillation takes place or not provided the motor is running under a constant load.

Dr. Duncan: I think the oscillation certainly would take place no matter what load is on the motor; because in a part of every period—and a period takes place every one three-hundredths of a second—the motor is not a motor at all, it is a dynamo. That is, it is absolutely putting current into the main line. The only way to get the energy and throw that current into the main line is by decreasing its speed and drawing from its energy of rotation. Therefore, where it is in those areas it will slow down in speed. Where it is in the larger areas it will increase its speed. But the oscillation will occur whether the load is constant or not.

Mr. Crocker: As regards the regulation of motors and the point that Mr. Mailloux brought out, it happens that one form of alternating current motor that I have been working on lately is particularly well adapted to being regulated. One of the most desirable means of regulation in any motor cannot be used in an ordinary direct current motor, on account of sparking; that is, the shifting of the brushes. When we reverse a motor by shifting the brushes, I mean shifting them right over, at first it would pass through the point of maximum sparking and would create a very serious trouble there, even when we reduce the power. It happens, as I say, that one form of motor works in exactly the other way, and that as you decrease the power you decrease the

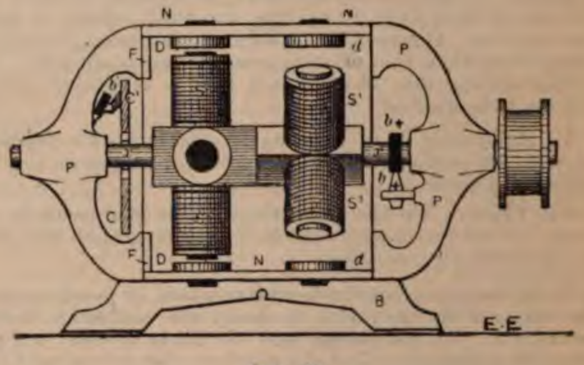


FIG. 11.

sparking, and when you reverse it there is no sparking at all. Therefore you can regulate it in that way, which is just the way everyone would like to regulate motors if he could.

Lieut. Patten: I have designed a form and made some elementary tests of a motor of the kind suggested by Prof. Elihu Thomson in his paper read before the Institute last spring. I have always regarded Professor Thomson's motor with a great deal of admiration. It would seem from some of the discussions we have listened to that whatever work we are going to get out of an alternating system must be a question of difference between two factors opposed to each other—the self induction of the circuit and the power generated as well as the heating. Inasmuch as all our results must be due to the difference between the two quantities, I have worked upon that line, trying to give that difference its greatest possible chance to do some work. If you will remember, Professor Thomson's motor as Dr. Duncan has explained it to-night, consists in a fixed field and a revolving armature, the circuit of which was closed when it came into position of action; at that point the circuit is momentarily closed.

Fig. 9 illustrates this principle. S is a solenoid with a soft iron core I, and D is a closed circuit of high self inductive capacity, pre-

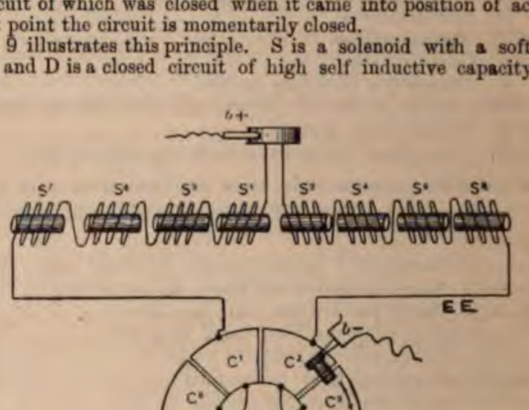


FIG. 12.

ferably a copper disc. When alternating currents are sent through the coils of the solenoid S, and the centre of the disc D is not immediately in the prolongation of the axis of the solenoid, there is a tendency to separate, as indicated by the two arrows. As in all forms of alternate current dynamo-electric machinery the effective effort is always due to a difference between two unequal and opposing actions, so in any machine in which the principle thus described finds application, the rotary torque or moment of rotation will be due only to a difference of two efforts, as shown in the preceding analysis; and the machine here illustrated is a simple mechanical arrangement of parts, the purpose of which is to cause this tangential effort, however small, to work at a possible maximum of advantage. Those who recall the forms of machine illustrated in a former lecture and based upon this principle will remember a form of machine not differing widely from the ordinary direct current machine. The armature placed at the centre of the machine consisted of a number of coils of high self-inductive capacity, the different circuits of which were closed in succession as they arrived in the position of maximum repulsive action. In the machine I have designed the application of the same

principle is reversed with the apparent effect of producing a more continuous rotary effort as well as a greatly increased moment of rotation by virtue of placing the point at which the effort is applied farther from the axis of rotation and thereby giving to the force at work, however small, a much greater lever arm. Figs. 10 and 11 are end and side elevations of the machine, and Fig. 12 is a diagram of circuits and connections. A polygonal frame F F F is connected by lateral strips N N, and all is supported upon the base B B. Secured to the lateral strips N N are two sets of copper discs D D and *d d*. These discs constitute the armature of the machine; they are arranged peripherally, as shown, fixed to the frame structure, and consist of circuits of high inductive capacity that remain permanently closed.

A spindle *x x*, Figs. 10 and 11, carries a revolving switch $C^1 C^2$, or sunflower, which is secured to the spindle and turns with it. This sunflower commutator constitutes one terminal of the machine, while an insulated ring *b* +, and its contact brush secured to the support P P, constitutes the other. Under each set of discs, D D and *d d*, and secured to the spindle *x*, is a set of solenoids. Those of one set being placed at an angle of 45 degrees to those of the other set, from which it results that these two sets of solenoids will each come alternately into action with respect to its own set of copper discs. Each set of solenoids has its four coils connected in series and the two sets are arranged in two independent circuits. Both have one terminal secured to the contact *b* +, and the other terminal to the alternate segments of the revolving sunflower. This system of connections is shown in Fig. 12, in which the eight-part commutator is shown with alternate segments connected to each other in separate series. The coils S^1, S^3, S^5, S^7, form one set of revolving solenoids connected in series from the rubbing contact *b* +, which forms one terminal of the machine, to the commutator segment C^1, and thence to all the odd numbered segments. In like manner the other set of solenoids S^2, S^4, S^6, S^8, are similarly connected in series to all the even numbered segments, C^2, C^4, C^6, C^8. From this arrangement it results that, as the spindle revolves, carrying these solenoids as a sort of fly wheel, the alternating current will be sent in rapid succession first through one set of solenoids, and then through the other, and by suitably placing this commutator upon the spindle it can be made to send the current through the different set of solenoids during the periods of maximum effort of repulsion between each set and its corresponding set of copper discs.

The moment of rotation is evidently a maximum under this system of construction, and by increasing the number of sets of solenoids that follow each other in action, the effort of the rotary torque may be made nearly continuous and constant.

It is evidently not contemplated that this motor shall drive horse cars. Its efficiency is not high, and its form renders such an application quite impossible, but it can find a place in the smaller industries, where light motors fill a definite requirement, and render an alternating current circuit a paying one during the working hours of the day.

Mr. Duncan in conclusion replied to some of the points brought up by the various speakers.

ZONE OF MAXIMUM INTENSITY IN ARC LIGHT.

According to the report upon arc lights of the Committee charged with the photometric tests of lamps shown at the last Antwerp Exhibition, if S equals the mean spherical luminous intensity, H = the horizontal luminous intensity, and M = the maximum luminous intensity, there exists between these three quantities the relation $S = \frac{H}{2} + \frac{M}{4}$. This empirical formula gives in most cases values which do not differ materially from those determined by exact calculation. The mean intensities of luminosity in each of the two hemispheres are fairly represented by $\frac{H}{4}$ for the superior hemisphere, and by $\frac{H+M}{4}$ for the inferior hemisphere. The zone of maximum intensity of light is the surface of a cone having the arc for its apex, and generated by a plane, one edge of which coincides with the vertical axis of the two carbons, the other edge making with this line an angle of about 50degs. It is to be understood, of course, that this zone of maximum luminous intensity is limited to the lower area of the conical figure thus described. This determination applies more particularly to arc lamps supplied by continuous currents.

Paris Exhibition, 1889.—We would remind intending exhibitors in the British Electrical Section of the meeting convened by the Society of Telegraph-Engineers and Electricians for Monday next, 19th inst., at 3 p.m., at the Institution of Civil Engineers, 25, Great George-street, Westminster. We believe that Mr. John Aylmer, the Society's representative in Paris, is coming over expressly to afford any further information that may be required by those who contemplate sending exhibits.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

DISCUSSION ON MESSRS. KAPP AND MACKENZIE'S PAPERS ON "TRANSFORMERS."

(Continued from page 235.)

Captain Cardew said he thought the chief theoretical novelty in this paper was the method given of making allowance for the power lost in heating iron core, the difficulty of which was that this loss of power affected to some extent the angles of lag, and unless they could allow for this the electrical power supplied could not be exactly computed, except, perhaps, by watt-meter. The assumption was that hysteresis produced an inductive effect always additive to that in the secondary coil, and if there were a true molecular friction this might be the case; but surely this was not the whole of the molecular forces, and the molecular forces as a whole opposed magnetisation and helped demagnetisation, while the friction alone opposed change of magnetisation. His ideas were probably very crude; but he looked upon a molecule of iron under cyclic changes of magnetisation as a straight spring bent first one way and then the other out of its natural position. When you bent it, there was opposing force; most of the energy was stored up and given out as the spring returned, but some was lost in friction. The risk to life from the use of the alternate transformer system had been the subject of anxious consideration, and, apart from any question of Government interference, it was certain that any serious accident would materially check the progress of the system. The risk could not be considered chimerical. They had in a transformer two conductors laid in close contact with each other, and with an iron core, and they were necessarily thinly insulated. One of these conductors might acquire at times any potential difference up to 2,000 or up to 2,400 volts over the other. He need not point out to this meeting that in the primary circuit, taken as a whole, there was certain to be a resultant leak. The other conductor had also its resultant leak, and this was likely to offer a resistance of not many thousand ohms. They had here what would be recognised by all who had worked much at cables and condensers, conditions favourable to an eventual breakdown. Seeing the obvious importance of some safeguard, he had waited in vain for its being brought forward, and he eventually attempted a solution himself, with a result they saw here—[pointing to an exhibit]. This iron box was a trap for leakage. This piece of aluminium foil—not platinum, as Mr. Kapp said—the lightest, not the heaviest metal—is what they might call the bait. It consisted of two round discs, separated by a narrower portion. This was laid flat in a shallow depression in the bottom of the box, which prevented any lateral displacement. There was also an insulated disc, which was just over the aluminium, and it was connected to a piece of very fine wire, which supported a spring. The box was connected to earth. The distance of the insulated disc could be adjusted by means of a screw. There was also a little disc which told them the distance at which the insulated disc was above the aluminium foil. This insulated disc was connected to any point on the secondary circuit through that piece of fine wire. Should the secondary circuit ever acquire a potential differing from the earth by more than whatever volts the safety device was set for—anything from 500 upwards—the aluminium foil was drawn up by the ordinary static attraction until it was in contact with the disc attached to the fine wire. The instant it was in contact with the disc of course it was repelled, but while in contact it had completed the circuit, and an arc would follow it, which, of course, quite instantaneously fuses the fine wire. As soon as the fine wire was fused, down came that spring and short-circuited the primary circuit, causing the double pole cut-outs to operate. He had here one of those little foils which had been used several times over. It was so little injured that it had been used again and again. It had stood an alternating potential of 2,400 volts. Professor Ayrton suggested these things were not necessary, because it was so easy to connect a secondary circuit to earth. That, of course, had occurred to a great many people. If they connected the secondary circuit to earth, at any rate it was all right for the customer. But putting the secondary circuit to earth insured that, as far as the secondary circuit went, there was no insulation, and consequently it practically did very much increase the strain on the insulation between the primary and the secondary circuit. Mr. Kapp described another device which had the same objects; he would only say, as a customer, he should be quite satisfied with it. As a maker of transformers, he should take it as a boon, because he should expect there would be a considerable demand for transformers. As a supplier of light, he should rather object to it.

Mr. A. Bernstein said he would confine himself to a very few questions, and those only in which he felt naturally most interested. One of these was that of putting transformers either in series or parallel. In a system of transformers, where they used high-tension alternating currents, the question of insulation became a very serious one, as they had just heard from Captain Cardew. If the used transformers in parallel, they were obliged to use two main conductors between which there was a very high difference of potential, say 2,000 volts, and they were further obliged to put them very close to each other in order to prevent induction on other wires. This made the insulation exceedingly difficult. Where they had transformers in series they only had the highest difference of potential at the dynamo end of the circuit, and they reduced the difference of potential constantly on their line, so that the mean difference of potential was only one half as much, and from the theoretical point of view one would say the tendency to produce a leak would only be a quarter as large. This, of course, was a very serious matter in the insulation of these conductors, but in addition to this the matter became of far more importance, even in the tranformer itself. In a transformer on a parallel system they had the same mean differ-

ence of potential of 2,000 volts between the ends of the coil, and as they could not use very heavy insulation in these coils if they wanted to have an efficient transformer, there was only a certain liability of leakage taking place. In a series transformer this difference of potential might be reduced to 50 or 100 volts, or just according to circumstances, and that enormously reduced the tendency to produce any leakage. Those were two very important advantages which the series system had over the parallel system, and they were so very important, as he said before, because the question of insulation in a transformer system was one which offered a good deal of difficulty. He would now turn to another point. That was the device to prevent the current going from the primary into the secondary. First of all they would see at once that where there was a tendency to short-circuit the primary with two thousand volts there was a tendency to heating. That destroyed the insulating material between the primary and the secondary, and there was a leak. The device of Mr. Kent might work very well, but it might, at the same time, do a great deal of harm if proper precautions were not taken. In using such devices as that of Mr. Kent proper precautions must be taken not to give the current a chance to leak from the primary into the metal plate, and from there into the earth.

Mr. Atkinson (of Halifax) said the few remarks that he would make referred principally to Mr. Mackenzie's paper. Mr. Mackenzie said that the great improvement of the last year or so had been the introduction of iron into the armature. He quite agreed with Mr. Mackenzie that the introduction of iron had been a great advance, but the mistake seemed to have been made of attempting to work the iron to the same degree of saturation as had been attempted in direct-current machines. The builders of the multipolar disc dynamos had found by experience that with more than six poles, at all events, there was great difficulty in keeping down the heating of the iron in the armature, however well it might be laminated. A short time ago he roughly made a calculation (taking that as a basis) of how many lines of force they might take in an alternate current machine without danger of heating from magnetic hysteresis. Thus assuming that a six-pole machine running at 600 revolutions with (taking Mr. Kapp's system of figures) about fourteen lines to the square inch, which he believed was about the maximum, they could work a machine of that size and speed, then with a sixteen-pole alternating machine at the same speed, and assuming there to be no greater hysteresis from viscosity, they could not use more than about nine lines to the square inch to produce the same amount of heat. That pointed at once to a considerable reduction in the density of magnetic lines to be used in alternate current machines. In the machine which Mr. Mackenzie had described he placed alternately coils on primary circuits separately excited, and similar coils differently wound formed an alternating circuit. Now it appeared to himself that on working this there would be produced equally in both of those coils an alternating electromotive force, and therefore, unless the machine was excited by a series dynamo, or some dynamo with considerable self-induction about it there would be a very large alternation in the exciting circuit, and as, generally speaking, continuous-current dynamos were not constructed to stand that it would produce rather a curious effect. He did not know whether Mr. Mackenzie had practically discovered that, or whether he had had any practical difficulty from that fact. He had brought there a photograph of the Connaught dynamo (shown) designed by Mr. Kapp, and constructed by Messrs. Goolden and Co., for producing alternate currents, which had iron in the armature. That particular machine was for 2,000 volts, 30 amperes, 600 revolutions, and weighed 2½ tons, which was about 90lb. to the unit, which was a pretty fair result. The armature was a large hub of cast iron or steel, on the rim of which was wound iron tape. On the other side of that was carried an iron wire—that is, because the magnets came over the top so as to laminate in all directions at right angles to the lines of the core, which was all securely riveted through, and they would see, coming through the hole there, driving spurs round the wire. The magnet ring was 40in. in diameter. There were 16 pairs of poles, and the speed at which it ran was 600 revolutions. That the thing was mechanically good was shown by this fact, that when it was running at about 1,500 volts, and at its full speed, it was accidentally short-circuited, which pulled up the engine, and gave the engine a considerable shock; but there was no damage done to the armature, and no wire shifted in the slightest degree. That was a pretty severe test, because the armature had a very low self-induction. Mr. Kingdon called attention to his machine as possessing this advantage that he could attach those inductors direct to the fly-wheel of an engine. He, himself, did not know what Mr. Mackenzie's experience with the owners of engines was, but he thought for one owner whom he would get to allow him to attach this kind of thing to the fly-wheel he would get about a hundred who would put on a pulley and would drive a machine that was going at another speed and could be conveniently put at any place they required. Moreover, he himself admitted the advantage of using a larger number of small machines, rather than one very large machine, which, in the case of a breakdown, would totally collapse. Further, a good deal had been made of the point that in machines of the class shown on the wall, what they might term the armature circuit (that is, the circuit which produced the current) was not moving, and that, therefore, the circuits might be coupled in parallel or series, as the case might be. He did not think anybody would attempt to alter the coupling of a machine of that kind giving 2,000 volts while it was running. Generally speaking it was only for experimental purposes that a machine of that kind was required.

Prof. Fleming said that he should like to describe some experiments that he made in 1885 in a couple of Zipernowski transformers, which were brought over and exhibited at the Inventions Exhibition. In that year Mr. Zipernowski brought over two of his now well-known lifebuoy-shaped transformers, and he placed them in the Inventions Exhibition, and he took the opportunity to make some experiments upon those transformers. He might mention that the transformers were wound in order to be arranged in parallel, and that they were worked from a self-exciting alternating current machine at some distance away, and in order to give the opportunity of seeing how this system adapted itself to the transmission of energy over great distances they placed the alternate current machine as far apart from the transformers as convenience would permit, and he believed that those transformers were a thousand feet away from the alternate current machine. Each of those transformers was intended to work a full load of 200 16-candle lamps, and they were connected by a No. 10 wire with the machine. He might mention that the primary current was operated by an electromotive force of about 1,000 volts. At that time Dr. Hopkinson had just drawn attention to some possible danger that might result from electrostatic capacity on the part of the transformers used, and it immediately occurred to the speaker, as it did to others at the same time, that that difficulty might be remedied or diminished by connecting the secondary circuit to the earth, and in these transformers exhibited in 1885 the secondary circuit was connected to an earth-plate. On mentioning this Prof. Elihu Thomson, of America, wrote to one of the technical journals to say that he had suggested that method before, and thereupon Profs. Ayrton and Perry wrote also to the same journal to say that they had suggested it before Prof. Elihu Thomson, and there the matter rested. He might also mention as an interesting fact in connection with these transformers that Mr. Zipernowski had arranged a method of self-regulation which was not very unlike that which had been sketched on the board by Prof. Ayrton. He could not for the moment trust his memory for the exact details of the method, but it would be found in one of Mr. Zipernowski's specifications for the year 1885. The principle of that method was the use of an additional transformer, which was so arranged that when the terminal volts at the main transformers were lowered this additional transformer raised them again, or tended to raise them again, to the normal value.

The meeting then adjourned.

Mr. Lamb commenced the adjourned discussion on February 23rd, and spoke of the experiments carried out by Prof. Ayrton to determine the efficiency of the Kapp and Snell transformer.

Mr. J. E. H. Gordon, while fully appreciating the scientific interest of these appliances and the great practical use that had been made of them, could not help feeling that it was a pity to see so much ingenuity, so much skill, and so much labour lavished on what, in his opinion—possibly he might be wrong—could only be intended for a makeshift to enable them to go on until something better was ready. If he might be pardoned for putting into a scientific discussion a word of autobiography he might say he was not altogether incompetent to speak on the development of alternate-current machines, for he supposed few people had been so deeply committed to them as he had been, or had to do with the actual practice of such large ones; and yet, even at the expense of abandoning every patent that he held, he had been so far convinced of the superiority of the method of distribution by storage batteries that he preferred to abandon his own system. They had all heard with a thrill of interest and delight of the 42ft. machines. It was not quite a new thing to think of these machines, although it was a new thing to give an order for them. He had made sketches of one—in fact, had gone as far as the working drawings—about a year and a half ago, and he admitted he was much tempted to go on. It would be very delightful to have such a machine. It would be worth running a great deal of risk merely to see such a mass of machinery moving and going round above your head; but to quote a French expression, "*C'est magnifique, mais ce n'est pas la guerre*," which may perhaps be translated by saying that that delight would be more felt by the engineer than the shareholders. He was not speaking of the abandonment of alternate-current machines, nor was he speaking of them as if they had been failures, or as if they did not work economically. His alternate-current installation at Paddington had worked for two years, and was now working; and in one year they had supplied 800,000 units of electricity. It was supplied at a price that was extremely low, and which they should not shrink from. It was only from reasons which he would give in a moment—which he hoped would be convincing—that he thought storage batteries were better; not because alternate-current machines were bad, but because he thought there was something else better, and therefore he had determined to abandon them. The first consideration was the space occupied by these machines. They knew that experiments had been made for employing a number of small alternate-current machines, and that these experiments had been successful at the South Foreland but that was because they were working with arc lamps. Many people had tried to work alternate machines in parallel, but they did not work together till they had jumped for three or four minutes. Now three or four minutes' jumping in the big machines might take a month's life out of 20,000 lamps, and that loss was rather a serious difficulty. Therefore they might take it in practice—he was not talking of what might be done in the laboratory—that they would not couple alternating machines, and that they must have very big machines if they were to get alternate currents to do the work. Those machines took up a dreadful amount of space. He did not think 10ft. diameter was an out-of-the-way size for a machine to give 200 to 250 units per hour, and that was what their Paddington machines were doing. Mr. Crompton was now making him machines with armatures 16in. in diameter, and two of these will do the same work as one of the 10ft. machines. If they had alternate current machines they must practically be placed outside the town, and the wires and mains must be brought into the town. But with these modern direct-current machines, and with modern engines such as Mr. Willans was making for them, they could pack the machinery so close that they could get an immense power in a small place, and none of their neighbours were any the wiser. His Company, the Whitehall Electric Supply Company, were, at this moment, putting in plant within a quarter of a mile of this place for 10,000 lights and had

room in the engine house to extend the supply to 20,000 lights. They were using an engine-house 86ft. by 40ft. That included boilers, batteries, and everything else. It might be said that 20,000 lights were a drop in the cup in London lighting, and they had to face the question as to whether they were going to put up very large stations or make numerous stations of about 20,000 lights. They all knew that one of the advantages of central station lighting was the great economy in management and working that was obtained by increasing the number of lights from one station. But that increase did not go on indefinitely. Now, if they had got about 500 lights, they would find, roughly speaking, that the cost for wages in the 500-light plant would be about 10s. per lamp per year. When they went up to 10,000 lights, they would reduce that to perhaps 1s. 2d. per lamp per year. But after 20,000 lamps they did not get any further decrease in the wages, because they must have more machinery—they must have more room and more men, and it increased *pro rata*. Therefore there was no doubt an advantage in having more than one station to work more than 20,000 lamps. They had the further advantage that if there were a number of stations of from 10,000 to 20,000 lamps, and they were working with direct current, they could couple those stations together. One might be working at one end of a main, and one at another; and if anything went wrong at one station the other station could help it out. There were certain definite reasons which he thought would always make a number of small direct-current machines more economical in working than any big machines, and he would go somewhat briefly into it. The first was a reason which he could explain better by a diagram, which he had had placed on the wall (Fig. 1), showing the curve of output of current for a residential district and taken from actual figures. That diagram showed that the maximum demand was very much greater than the average. Hotel districts and club districts showed different curves. The diagram represented hours from six one morning to six the next morning. The vertical ordinates showed the number of lamps, and assuming that the installation was wired for 20,000, the number of lamps was small till about three o'clock, say, on a winter afternoon. Then it rose pretty steadily and regularly till about six o'clock. Then it went up in a rush. Then it came down and remained pretty nearly constant from about half-past eight till about ten. That was the time when the first batch of people went to bed. Then it sank gradually. There was apparently a great line of virtue about ten o'clock. People who stayed up after ten o'clock seemed to be reckless of hours of morality, and merely dropped off one by one until the morning. The reason of the rise between seven and half-past was rather curious. That was the time when people went up stairs to dress for dinner. About the same time the servants are laying the cloth in the dining room. So it happened that that was the only time that the lights in the dining room and the bed rooms were lit at the same time. That sent the current up with a rush. Assuming that they were working with an alternate-current machine, with 20,000 lights wired, and they had, say, 15,000 lamps in use, in order that there should not be a breakdown they must have their machine powerful enough for 15,000, and that meant not only that the alternate-current machine, but that the engine, boilers, dynamos, and engine house must all be up to that size. Assume also that they were supplying by a contract based on meter. It would then be evident that a great portion of the machine was only earning money for an hour and a half in the 24 hours, and that half the power of the machine was wasted for at least 12 hours out of the 24. But the interest on the cost of the machine was going on for the whole 24. Now let them see what would happen if they had storage batteries. Assume first of all that they were going to have a moderate amount of storage, and would work their machines for 12 hours. The quantity of electricity for the day was shown by the area of the demand curve; that showed the number of units—and the area of this second curve, or 12 hours' supply, must be the same as the area of this other curve, showing the quantity required for the day. If they had storage and worked their engines for 12 hours, the maximum current need only be a current for 4,550 lamps. The size of the engines, burners, and boilers was fixed by that. Therefore, for 20,000 lamps, with an occasional supply of 15,000 at once, it was not necessary to have, by storage, machinery of greater capacity than 4,550. If, however, they decided to work their engines for 24 hours—which might in some circumstances be advisable—they could then have something much smaller still. He supposed in practice, what they would do in designing a new installation would be to so arrange that the engines, when they are first put down, are to work twelve hours to meet the demand, and then as custom comes in they could decide according to circumstances whether they would increase their engine power, or whether they would increase their battery power and work longer hours. But probably they would commence working twelve hours and increase the hours of working as custom came in. He must further point out that whatever percentage loss there might be in the storage batteries must be calculated not on the whole area of the curve but only on those portions of the supply and demand curve which do not overlap—a very different thing. That dealt with the capital cost of the plant. The next point was the efficiency of the dynamo. Mr. Mackenzie knew perhaps even better than he himself did that the efficiency of the alternate-current dynamo was quite different when it was fully loaded from what it was when not loaded, and the alternate-current dynamo that would give, say, 4,000 horse-power a day, and give a very good efficiency, say 90 per cent., or whatever it might be, would not have anything like that efficiency when the dynamo was working at a half or a third or a quarter of its power. There was, however, a much more important point than that. The alternate-current machines, whether used direct, as was their practice in Paddington, or when used in these transformers, required for their successful adoption that the number of alternations per second should be sensibly constant—that is, they must not greatly vary the speed of the engines and the speed of the dynamos. They must run their engines at very nearly the same speed, whether they were giving their full power, or whether they were giving only a fraction of their power. He would ask them what the diagram of a quadruple expansion engine of 5,000 horse-power would be, working at full speed at 1,500 horse-power? Probably two cylinders would be working one way, and pulling the the other two round; and the diagram would be of a somewhat peculiar nature. Experience showed that a compound engine, working at full speed at a third of its power, burnt at least twice as much coal per horse-power as when it was working at its full power. Now, these smaller engines that were used for storage current might be easily coupled together. They worked their engines at their full power until they had obtained the storage they wanted, and then they stopped. The engines were either worked at their full power or were stopped. Therefore they were bound to get a far better economy than could be obtained by working big compound engines at half their power. There was another reason for scattering stations and placing them where you could use engines that would not be a nuisance in great populous districts. London was now being filled with great buildings, residential flats, great hotels, and buildings of that sort, and the best site of a station was somewhere near one of these, where they could use their lamps to begin with, as there they could for the first time meet the gas companies on their own

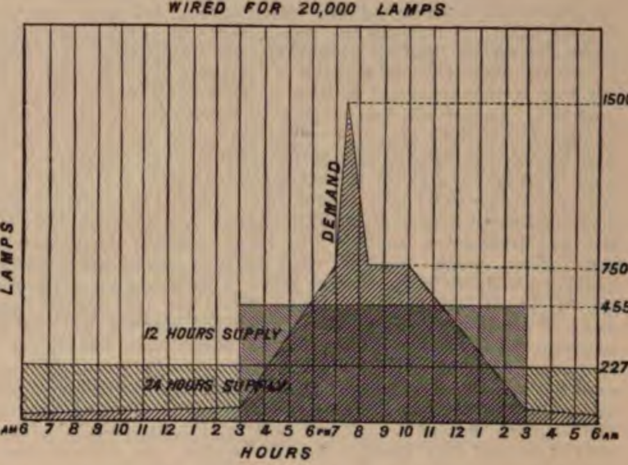


Fig. 1.

ground, and utilise *waste products*. At Whitehall he had taken a contract to sell a quantity of hot water day by day that would use up the whole of his waste steam, and thus what was formerly an expensive nuisance was converted into an important source of revenue. He did not, however, wish to be too precipitate in his condemnation of the transformer. These were two systems, both endeavouring to do their work as best they knew. He felt that his friend Mr. Mackenzie was doing good work in educating the public to the use of electric light, and persuading them to wire their houses. Mr. Mackenzie's customers would, he hoped, then transfer their custom to him on seeing the advantages of the storage system. Perhaps they must not allude to it too particularly, but they might remember that there was yet a third system of electrical distribution which they had heard of a great deal within the last few weeks, which he thought none of them would wish to assist more than they could, and that was the system of distributing electricity from house to house by means of circulars.

Mr. Crompton said they were discussing two papers on transformers, and he thought his friend Mr. Gordon had rather wandered away from the subject. He hoped they would check him if he wandered away in the same direction, because there was a great tendency to do so. The subject of transformers, taken by itself, viewed more particularly from the side Mr. Kapp had viewed it, was of a somewhat dry nature, and they would, he hoped, excuse him if he tried to infuse a little more liveliness into the discussion. The lighting of the future, so far as they knew at this present moment, was going to be handed over to the one system or the other, to battery transformers or to alternate-current transformers. He considered that the question that these papers had raised at the present moment were of supreme importance. The company that he had been more particularly speaking of—for which they had the highest respect—the Grosvenor Gallery people, had done a very great work, and he thanked them most heartily for educating the people of London to like the electric light. They were showing how people would put up with any sort of light, It was very difficult to follow a very good man over his ground, but it was very much easier to beat a man who was not quite so good, and in that case he thought the Grosvenor Gallery gentlemen would excuse him if he said that they had a little to learn still in the way of producing the electric light. Hitherto they had produced scintillations which were not altogether pleasant to people who were sitting at five o'clock tea in a Mayfair drawing room. He believed that Mr. Mackenzie had explained many of the causes of these things, which of course they must not laugh at; but as an opponent he took advantage of them, because he believed they were inherent in the system. He believed that with the alternating transformer system, as at present arranged, they were greatly dependent on what their neighbour did, and that accidents to their neighbour's transformer affected an innocent person several blocks off in a way that could not happen with the direct system by distribution carried on from a series of accumulating or storage centres. He had long had the two systems before him, and he had been working

at the subject for the last two or three years. As most of them knew he had carried out central stations in which the transformation from high-tension currents of 500 volts had been carried down to 100 volts, usually employed in incandescent lamps by means of four batteries in series. He had data from these installations, and data which were of use. It was no use in such a place as that to discuss the question of management—that is to say, wages and matters of that kind—but it was of great use to discuss the scientific engineering part of it, that is, the question of which system worked with the least horse-power, which worked with the least first cost in machinery, the least first cost in mains, and the greatest steadiness and regularity and freedom from breaks down. From these points of view he proposed to compare the system of alternating transformers with the system of battery transformers.

At this stage he would remind them of the tremendous leg-up which the alternating transformer system had received from Mr. Westinghouse. Westinghouse was one of the most wonderful men in the world. There was no man like him as an organiser of labour and as an organiser of machinery. Witness his brake. In the face of the most tremendous opposition from the railway authorities, he had made his brake almost universal, and he had done that with all these peculiar powers. He was a very rich man, and he had unexampled facilities at the town of Pittsburg, where his most successful lighting had been carried out. But he would tell them that what Westinghouse had done for the transformer system was exactly what Brush did for arc lighting when they used arc lighting—they might say for the first time—in England a few years ago. He had turned out from a well-appointed factory complete, well-considered sets of machinery, packed and sent away to any township in America that wanted electric light of a sort. It could be put up in the way that American electric lighting machinery was done—very roughly—on the spot. But the things were so well appointed and so well made in the factory that they could be erected at small cost, and in sufficiently good rough-and-ready fashion to suit the American taste. Anybody who had been in America, anybody who knew anything about American installations, would confirm what he was saying—that electric lighting machinery in America as made in the shops was perfection; but the putting of it up was such as would not pass muster in the worst of our English installations. That had been the case with the enormous list of transformer machinery that had been carried out by Mr. Westinghouse. Although that was perfectly suited for such countries as America and Australia, countries where rough workmanship and such things did, it was quite unsuited for civilised countries. The alternate-current transformer was well suited for such cases, but the moment they brought it into London, the moment that it was no longer a rover, as it was at present, over the tops of the houses, the moment they confined it under the streets, then it lost all its advantages. What were its advantages? Its advantages were that they could put down a station, and they could run wires anywhere they pleased, on account of the peculiar state of the law, and take up a number of customers that otherwise they could not reach at all. But he said that when the taste for electric lighting became more universal, when two in every three people along the line of streets took the light—that such a system of overhead mains and that kind of thing was intolerable; and there must come the day when mains had to be laid, as they had been successfully laid under the streets, and then they would find that the alternate transformer system was out of it as compared with the other. He was glad to see that Mr. Kapp, in his paper, practically admitted that. He admitted it in his last sentence, and a man puts his sense in the last sentence of his paper. The fact of the matter was, when Mr. Kapp said they would have to lay down a network, and when Mr. Mackenzie said they would have to lay down a network, he would like to know in what way they would lay down a network cheaper than the batteries. The mains could be laid in the streets from 14s. at the lowest to 16s. or 18s. a yard at the highest. The smallest section of copper could not be put in under 14s., and 16s. or 18s. would give them a very fair section of copper quite sufficient for an ordinary length of streets. When people talked of copper as if copper were the only thing that had to do with the cost of conduction, they were talking nonsense. This was not the place to go into a long comparative estimate as to the cost of the two systems; suffice it to say, he had figures in his possession that he had worked out very carefully. He would not take the extreme figures mentioned by Mr. Mackenzie, who assumed 100 volts and transmitted it through an inch and a half cable with 1,500 amperes at 100 volts potential. By taking 500 volts, which was workable for a distance where the generating station was situate from a mile to two miles from the centre of the district to be supplied, the cost of the two systems works out practically identical. That was to say, if 10,000 lights had to be supplied in a town, with the generating station situate not more than two miles from the centre of the supply, the cost of those 10,000 lights—and he called the maximum number at one time 10,000 lights—the cost was identical in the two cases, and there was no saving by using the alternate system. Now he would attack the alternating system as an efficient one. They had heard a lot about the efficiency of transformers. There had been a fight over a few places of decimals. That was whether they were 80 or 90 per cent. They had got efficiencies showing that at a very low heat indeed the true efficiency was as high as 80 per cent. of the transformer, and he did not believe that. The large transformers that would have to be large enough to go up to the peak of the diagram shown by Mr. Gordon, but when they were working in the daytime, they would not be working at much more than 15 to 20 per cent efficiency. Further than that, those transformers were worked by very large dynamos. Mr. Mackenzie talked about 42ft. 5,000 horse power dynamos, and they were told that the total size of the station was 20,000 horse-power. He would like to know how many tons of coal per lamp (laughter) it would take to work those amps at the day-time. He had made some experiments in this direction, and he knew from experience in years gone by, and from later experience, what it meant to run engines even with continuous currents, without the aid of batteries, *i.e.*, to run them nearly empty. There was not a more extravagant beast on the face of the earth than a compound or triple expansion engine worked down to a fourth or a fifth of its full output. As Mr. Gordon said, the two other cylinders were nothing more nor less than air pumps—drags on the engine, and Mr. Willans could tell them a great deal better than he could what they would do. They might put it in this way: These big engines used about two-thirds of the coal when empty that they did when full—that is to say, if using 20 tons a day when full, when they were running one lamp they would be using about thirteen or fourteen. So they could see what it came to. Everybody who worked central stations knew these facts. Mr. Mackenzie knew them. He knew how much coal they were burning now at the Grosvenor Gallery, and he (Mr. Crompton) knew, and he could tell them they were burning five times as much coal at the Grosvenor Gallery, lamp for lamp, as he burnt at Vienna. That was because *he* employed accumulators, and *they* were wasting their coal by having to keep a big engine running for long hours when there were very few lamps on. If Sir Coutts Lindsay had asked him to put up a battery system about two years ago, Sir Coutts would have saved enough money in his coal bill from the time he started to pay for two new batteries. Mr. Gordon's diagram was almost an exact copy of half-a-dozen diagrams that had been shown to himself this evening by Dr. Fleming, which had come from the Edison Company in America, and referred to various installations. That diagram of Mr. Gordon's, which he knew was founded on London experience, was almost a correlation of work that he had done at Vienna, and it was exactly corroborated by those most interesting diagrams that Dr. Fleming had got, which pointed out that there were peaks for only an hour or a couple of hours' duration, when the demand was nearly double that of the other maximum demand—he meant by the latter the demand that lasted for three or four hours—and something like ten or twelve times the average demand. He thought the whole pith of the economical question lay in studying diagrams of this kind. The whole thing was turning on the one question that was raised by Mr. Mackenzie. Mr. Mackenzie had thrown doubt on the question, which had been over and over again asserted, that they could not run alternate-current machines in parallel. If they *could* run them parallel, that would knock the bottom out of a great many of his (Mr. Crompton's) arguments. There was no doubt about that. But it had not yet been done—he had taken very great pains to find out whether it had been done in practice—but it certainly had not been done here in England, and it had not been done in America otherwise than experimentally. When these gentlemen could use them so that they could follow the lines he did of putting one dynamo on after another, and working them up to their full capacity and their best efficiency as the demand arose, and fill up the sharp angles between the dynamos by working accumulator in parallel to them—till these gentlemen could do that they would never approach the efficiency that he had at present. He believed from Mr. Mackenzie's statements and from all the rest he could hear, that Signor Ferranti had virtually admitted that they could not put the machines parallel by his desires to construct these gigantic machines that were mentioned in the paper.

(*To be continued.*)

COMPANIES' MEETINGS.

THE PILSEN-JOEL ELECTRIC LIGHT COMPANY.

An extraordinary general meeting of the shareholders in this Company was held on Tuesday at the Cannon-street Hotel.

Mr. R. W. Rawson, who presided, proposed: "That if an order of the Court be obtained for confirming this resolution, the capital of the Company be reduced as follows:—(*a*) By reducing from £2 to £1 per share the nominal amount of the 3,517 shares of the Company of £2 each which have been forfeited, and are now unissued. By cancelling, as being capital which has been lost, or is unrepresented by available assets, the sum of £1 per share on the 24,483 shares of the Company of £2 each, with £1. 5s. called up thereon, being the shares numbered 1 to 28,000 inclusive, with the exception of those mentioned above in Clause (*a*), and the sum of £1. 16s. per share on the fully paid-up shares of £2. 5s. each, being the shares numbered 39,351 to 39,450 inclusive. And that the memorandum of association of the Company be modified, so as to carry into effect this resolution."

The **Chairman** having explained the object of the resolution, **Mr. Fyfe** severely criticised the whole of the proceedings, and informed the shareholders that two of the directors, Major Scriven and Mr. Whately, were disqualified, because they had not a sufficient number of shares. This statement caused considerable disorder, but it was generally accepted by the shareholders.

Mr. Samuel, in strong terms, alluded to the whole of the proceedings as illegal.

The **Solicitor** was asked whether Mr. Fyfe's remarks were authentic, and in answer he stated that they were. The directors were therefore no longer qualified for their office.

Mr. Fyfe then proposed, and **Mr. Hutton** seconded, an amendment for the adjournment of the meeting for a month, and that a committee of shareholders be appointed to investigate the statement contained in the notice convening the meeting, to confer with the chairman and late directors, and to report thereon, and generally upon the business of the Company at such adjourned meeting, and in the meantime the chairman and secretary be authorised to continue the business.

The resolution was unanimously agreed to.

PROVISIONAL PATENTS, 1888.

MARCH 2.

3215. **Improvements in electric incandescent lamps.** John William Oldroyd, 8, Quality-court, London, W.C. (Complete specification).

3223. **Improvements in secondary batteries.** William Kingsland, 49, Cambridge-road, Gunnersbury, W.

3230. **Improvements in electrical tramways and railways.** Frederick Charles Allsop, Bexley, Kent.

3235. **Improvements in multipolar dynamo-electric machines.** George Miot, 46, Lincoln's Inn-fields, London, W.C.

MARCH 3.

3286. **Improvements in electrical measuring instruments.** George Leonard Addenbrooke, 9, Mecklenburgh-street, W.C.

3303. **Improved apparatus for registering the consumption of electric energy.** Henry Harrington Leigh, 22, Southampton-buildings, Chancery-lane, W.C. (Jean Louis Clerc, Paris).

3312. **An improvement in voltaic batteries.** Edward Tyer, 28, Southampton-buildings, Chancery-lane, London, W.C.

3328. **Improvements in electric contact makers and commutators.** Charles Langdon-Davies, 110, Cannon-street, London.

MARCH 5.

3359. **Improvements in apparatus for operating or controlling type-setting machines, type-writers, and the like by the aid of electricity.** Edward Fitzgerald Law, 45, Southampton-buildings, London, W.C.

3369. **Improvements in the treatment of zinc and its ores.** Alexander Watt, 6, Bream's-buildings, Chancery-lane.

3371. **An improved method of attaching the caps, or covers of electrical fittings to their bases so as to form an air-tight joint.** Charles Cross Falkenstein and Samuel Sudworth, 23, Andalus-road, Clapham, S.W.

MARCH 6.

3456. **Improvements in electric bells or wringing apparatus.** William Howard Winnall, 4, South-street, Finsbury, London.

MARCH 7.

3483. **Improvements in electrical switches.** Frederick Thomas Schmidt, Sunbridge Chambers, Bradford, Yorkshire. (Complete specification).

3498. **Improvements in and relating to alternating current dynamo-electric machines.** Thomas Parker, 70, Market-street, Mancheseer.

3504. **Multiple electric communication.** James Oldfield, 30, York-street, Westminster, London.

3517. **Improvements in primary batteries.** Robert Disher, 1, Quality-court, W.C.

3535. **Improvements in electric conductors.** William Bowers Fitch, 4, South-street, Finsbury, London.

MARCH 8.

3550. **An electrical regenerative battery.** Norcliffe George Thompson, 4, Queen Victoria-street, London, E.C.

3571. **Improvements in telephonic transmitters.** Thomas Laurie, 115, St. Vincent-street, Glasgow.

3590. **Improvements in electrical transformers and plates therefor.** John Grice Statter, Norfolk House, Norfolk-street, London, W.C.

3593. **Improvements in the construction of cells or jars of electric batteries.** Robert Walker, 39, Delorme-street, Fulham, S.W., Middlesex.

3614. **Improvements in dynamo-electrical machines.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MARCH 1, 1887.

3158. **Improvements in machines for giving currents of electricity on the insertion of a coin, token, or the like.** Percival Everitt, 4, South-street, Finsbury, London.

MARCH 23, 1887.

4369. **Improvements in instruments for detecting and measuring electric currents.** Philip Jolin, 35, Narrow Wine-street, Bristol.

APRIL 6, 1887.

5140. **Improvements in galvanic batteries.** William Henry Quarterman, 21, Cockspur-street, London, S.W.

APRIL 7, 1887.

5193. **Improvements relating to a system of generation and distribution of electricity.** George Annesley Grindle, 79, Cambridge-gardens, Notting Hill, W.

APRIL 29, 1887.

6267. **Lock switches for use in electric circuits.** Arthur Cecil Cockburn and Eustace Thomas, 26, Petherton-road, Canonbury, N.

MAY 5, 1887.

6590. **An improved magneto-electric cut-out.** William Harding Scott and Edward Alexandre Paris, 1, Queen Victoria-street, London, E.C.

6621. **An improvement in electro-motors.** Joseph Devenport Finney Andrews, 28, Southampton-buildings, Chancery-lane, London, W.C.

MAY 25, 1887.

7548. **Improved method of transmission through submarine cables and apparatus therefor.** John Gott, 3, Church-court, Old Jewry, E.C.

7611. **Improvements in submarine cable grapnels, grapnel rope couplings and connections.** Walter Claude Johnson and Samuel Edmund Phillips, 28, Southampton-buildings, Chancery-lane, London, W.C.

MAY 26, 1887.

7675. **An improvement in mushroom anchors.** Walter Claude Johnson and Samuel Edmund Phillips, 28, Southampton-buildings, Chancery-lane, London, W.C.

OCTOBER 4, 1887.

13,447. **Improvements in electric railways and tramways.** Alexander Login Lineff and Edward Hodson Bayley, 6, Bream's building's, E.C.

SPECIFICATIONS PUBLISHED.

1887.

3225. **Generating and distributing electric energy, &c.** R. Dick and R. Kennedy. 8d.

4322. **Dynamo electric machines.** J. and E. Hopkinson. 11d.

4472. **Electro-deposition of cobalt.** S. P. Thompson. 6d.

4978. **Holder and switch for electric lamps.** F. T. Schmidt. 8d.

4980. **Making and breaking electrical circuits.** F. T. Schmidt. 8d.

5009. **Secondary batteries.** J. T. Armstrong. 6d.

5092. **Switches for electrical purposes.** B. Egger. 8d.

5228. **Holders for incandescent electric lamps.** W. H. Bayley. 8d.

5707. **Automatic cut-outs for electric arc lamps.** E. F. H. H. Lauckert and H. W. Kingston. 8d.

6972. **Obtaining derived currents of variable intensity from a main electric current.** J. C. Mewburn. (La Société Anonyme pour la Transmission de la Force par l'Electricité). 8d.

1886.

1235. **Incandescence gas lights.** C. Von Buch. 8d.

CITY NOTES.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ending March 9 amounted to £4,668.

Brazilian Submarine Telegraph Company.—The directors of this company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, payable on the 24th inst.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ending March 9, after deducting the "fifth" of the gross receipts payable to the London Platino Brazilian Telegraph Company, Limited, were £3,881.

Alfred Slatter and Co. (Limited).—The usual notice has been given in the *Gazette* for creditors to send in their claims to the official liquidator, Frank Day, of 45, Tabernacle-street, Finsbury-square, on or before the 4th day of April. The place and day fixed for hearing and adjudicating upon the debts and claims is at the Chambers of Mr. Justice Kay, at the Royal Courts of Justice, on Wednesday, the 11th April, at 12.

Direct Spanish Telegraph Company.—The Directors of the Direct Spanish Telegraph Company, upon the accounts for the half year ending December 31, 1887, being submitted to them, decided, subject to their being audited, to recommend the payment of a dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend of 2¾ per cent. (free of income-tax) for the half year upon the ordinary shares, making, with the previous distribution, 4 per cent. per annum for the year 1887.

Eastern Extension Co.—The Eastern Extension, Australasia and China Telegraph Company (Limited), announce that their accounts to December 31 last show, subject to audit, a balance of profit of £121,800, after payment of three interim dividends. The directors now propose to distribute on April 26 the usual dividend of 2s. 6d. per share, making a total dividend of 5 per cent. for the year 1887. It is also proposed to pay a bonus of 3s. per share, or 1½ per cent., making a total distribution of 6½ per cent. for the past year, against 6 per cent. in 1886. The balance of £53,000 has been carried to the reserve fund, which now stands at £620,000.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.	Dividend.		Name.	Paid.	Price. Wednesday
3 Jan.	4%	African Direct 4%	100	101	1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105x
12 Feb.	1/2	Anglo-American Brush E.L.	4	3	28 July	10/0	India Rubber, G. P. & Tel.	10	16⅜x
12 Feb.	2/0	— fully paid	5	4¼	28 Oct.	12/6	Indo-European	25	40
15 Feb.	10/0	Anglo-American	100	41	16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
15 Feb.	20/0	— Pref.	100	66	16 March ...	5%	Maxim Weston	1	3-16
12 Feb., 85...	5/0	— Def......................	100	15	15 May	5%	Oriental Telephone	11	½
29 Dec.........	3/0	Brazilian Submarine.........	10	12	14 Oct.	4/0	Reuter's	8	8¼
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	3½	2½
15 Feb.	8/0	Cuba	10	12¾	15 Feb.	15½%	Submarine	100	145x
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	97
14 Oct.	1/0	Direct Spanish	9	3¾	14 July	12/0	Telegraph Construction ...	12	39
18 Oct.	5/0	— 10% Pref.	10	9½	3 Jan.	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	8⅝	30 Nov.	5/0	United Telephone	5	14⅛
12 Jan.	2/6	Eastern	10	11½	......	...	West African	10	5
12 Jan.	3/0	— 6% Pref.	10	14⅞	1 March ...	5%	— 5% Debs.	100	93
1 Feb.	5%	— 5%, 1899	100	105½	29 Dec.........	6/0	West Coast of America ...	10	5⅝
28 Oct.	4%	— 4% Deb. Stock	100	106	31 Dec.	8%	— 8% Debs.	100	116
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12⅜	14 Oct.	3/9	Western and Brazilian......	15	9½
					14 Oct.	3/9	— Preferred	7½	6½
1 Feb.	6%	— 6% Deb., 1891	100	106	......	...	— Deferred..................	7½	3¼
3 Jan.	5%	— 5% Deb., 1900	100	105	1 Feb.	6%	— 6% A	100	110
2 Nov.	5%	— — 1890	100	103	1 Feb.	6%	— 6% B	100	105
3 Jan.	5%	Eastern & S. African, 1900	100	104½	......	...	West India and Panama ...	10	⅞
12 Jan.	5/9	German Union	10	9¼	30 Nov.	...	— 6% 1st Pref.	10	10
27 Jan.	1/6	Globe Telegraph Trust......	10	5¾	13 May, '80...	...	— 6% 2nd Pref.	10	6½
27 Jan.	3/0	— 6% Pref.	10	13⅜	2 Nov.	7%	West Union of U.S..........	$1,000	125
3 Jan.	5/0	Great Northern..............	10	14¼	1 Sept.	6%	— 6% Sterling	100	101x

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Feb. ...	£38,795	+ £3,242
Brazilian Submarine	W. March 2 ...	£4,435	...	Great Northern	M. of Feb. ...	20,400	...
Cuba Submarine	M. of Feb. ...	3,600	+ £591	Submarine	None	Published.	
Direct Spanish......................	M. of Feb. ...	1,858	+ 235	West Coast of America	M. of Feb. ...	4,625	...
— United States	None	Published.	...	Western and Brazilian	W. March 2 ...	3,766	...
Eastern................................	M. of Feb. ...	51,261	+ 4,361	West India and Panama	F. Feb. 29......	3,139	+ 299

Abbreviations: W., week; F., fortnight; M., month.

NEW ELECTRICAL COMPANIES.

The St. James's and Pall Mall Electric Light Company, (Limited).—Registered by Trinders and Co., 47, Cornhill, London, E.C. Capital £100,000, divided into 19,980 ordinary shares of £5 each, and 100 founders' shares of £1 each The founders' shares shall confer on the holders thereof the right to one-half the net profits the Company made in each year which shall remain after paying or providing for the payment of a dividend of 7 per cent. for such year on the capital paid up on the other shares. Object: to erect a central station or stations for creating, producing, storing and supply of electricity, electrical motive force or similar agency for lighting, heating and motive purposes, or otherwise, in the district of St. James's and elsewhere throughout the metropolis. The first subscribers are:—

	Shares.
George Edward Francis, retired colonel, 55, Victoria-street, S.W...	1
Latimer Clark, civil engineer, 6, Westminster Chambers, Victoria-street, S.W.	1
Ernest Edmund Molyneux Royds, gentleman, Broadview, Petersfield, Hants	1
Peter Penn-Gaskell, justice of the peace, 12, Albert-mansions, S.W.	1
Edward Matthew Palliser, retired captain, 91, Earl's Court-road ...	1
Arnold Trinder, solicitor, 47, Cornhill	1
Eustace Jeune Anthony Balfour, architect, 32, Addison-road, Kensington, W.	1

The number of directors shall not be less than three, nor more than eight, unless otherwise directed at any time by the Company in general meeting. The first directors shall be Eustace J. A. Balfour, Latimer Clark, P. Penn-Gaskell, Ernest Molyneux Royds, and Colonel G. E. Francis. The qualification of a director shall be the holding of not less than 100 shares of £5 each, or any equivalent amount of other shares in his own right. The annual remuneration of the directors (exclusive of any managing director) shall be £1,000 per annum, or such larger sum as may be equal to 10 per cent. of the net profits; but such remuneration shall not exceed £1,500 in any year.

Charles L. Baker and Company (Limited).—Registered by Rowley and Co., 3, Great Winchester-street, E.C., with a capital of £25,000. Object, to acquire on the terms of a provisional agreement dated the 19th of November, 1887, and made between Chas. L. Baker of the one part and Frederick Murgatroyd of the other part, with such modifications (if any) as the directors of the Company may think fit, the business of Charles L. Baker and Co., telegraphic electric, surgical and scientific apparatus makers, of Worsley-street, Chester-road, Manchester, as a going concern, including or together with the goodwill of the said business, the right to use the style of the said firm, and all trade marks used in the said business and the benefit of all pending contracts entered into by the said firm, and the lease of the premises in Worsley-street aforesaid, occupied by the said firm, and all patent rights, plant, utensils, stock-in-trade, work in progress, patterns, drawings, electros, fittings and effects owned by or belonging to the said firm in connection with the business. The first subscribers are:—

	Shares.
C. Baker, Cornbrook Telegraph Works, Manchester	1
J. Johnson Bennett, Seymour-grove, Manchester............	1
G. W. Locock, 2, Brooklyn villas, Old Trafford, Manchester	1
T. Pilling, 2, Booth-street, Manchester	1
F. Murgatroyd, 2, Booth-street, Manchester..................	1
W. Penman, 6, St. Bees-street, Manchester	1
J. Witham, 72, Bury Old-road, Manchester	1

The first directors shall be James Leigh, J. E. Longson, Thomas Horsfield, W. B. Lowcock, Charles Sacré, John Hugh Penman, John Knowles Glazebrook, and Charles Laurence Baker. Qualification, the holding by each of at least 250 shares in the Company in his own right. Charles Laurence Baker shall be managing director at a salary of £500 per annum.

Exeter Electric Light Company.—A company has been registered under this title, with a capital of £20,000 in 2,000 shares of £10 each, the first ten of which will be Founder's shares. The prospectus states that nearly one half of the share capital has been already assured. The directors are:—

William Horton Ellis, J.P. (chairman), Hartwell House, Exeter.
Laurence J. Kennaway, Homefield, Exeter.
Walter Pring, J.P., Northlands, Exeter.
C. J. B. Sanders, Crescent House, Pennsylvania, Exeter.
G. F. Truscott, Baring Crescent, Exeter.
Henry George Massingham, Taunton Electric Lighting Company (Limited), managing director; (will join the Board after allotment).

The Company is formed for the purpose of supplying electricity, both as a light and motive power, to Exeter. The Company has secured the right to use the waterpower at Trewsweir to the extent of 100 effective horse-power in perpetuity, at a price which, according to the prospectus, will be a great saving over the cost of steam power. The public meeting, as we have already intimated, some weeks ago declared in favour of the electric light, and a memorial is in course of signature, and has already been signed by over 3,000 citizens for presentation to the Town Hall. Over 170 citizens have expressed their willingness to adopt the electric light in their houses and places of business. The system which it is proposed to adopt is that of the Thomson-Houston, and the work will be carried out by Messrs. Laing, Wharton, and Down.

NOTES.

Cable Repaired.—The Eastern Telegraph Company announce that the Perim-Suakin cable is repaired and communication with Suakin restored.

Senegal.—The electric light is about to be established at St. Louis, in Senegal, and the plant required for this installation has recently been forwarded from Bordeaux.

Windmills.—It will be found that one of the first persons, if not the first, to use windmills as the motive power for driving dynamos to charge batteries was Prof. Blythe of Glasgow. Much has been made of certain French experiments, but surely there is nothing novel in such a proceeding.

Prestbury.—The Committee, at the last meeting of the highway board, recommended that the Lancashire and Cheshire Telephone Company be permitted to erect the necessary posts for their line between Adlington and Poynton, on payment of 1s. per post per year. The Board agreed to this, and ordered the common seal of the Board to be affixed to the agreement.

Switzerland.—The electric tramway at Vevey-Montreux was successfully worked for the first time on the 27th ult., over a length of 11 kilometres. The Montreux station will supply the electric light throughout the neighbourhood, by means of alternating-current machines and transformers. Some of the subscribers have had the light in their houses for several weeks past.

A Long Lamp Life.—Mr. Gilbert Wilkes, Ensign U.S. Navy, referring to the statement that a certain incandescence lamp had been maintained in action for the long period of 5,292 hours, testifies that when the U.S.S. "Trenton" returned from China in 1886, one Edison lamp, of which, together with many others, a very careful record was kept, had burned 9,700 hours, and was still in good condition.

Electric Railway.—As stated last week, M. Fischer, a Viennese engineer, has obtained the concession for an electrical railway between Voslau, near Baden, and Leopoldsdorf, a distance of 27 kilometers. We are further informed that the line is to be worked by means of accumulators, and that, with a view of securing the best for the purpose, comparative trials are about to be made of the E.P.S. and the Julien batteries.

Electric Bells.—An interesting popular lecture on these useful appliances was recently delivered by Prof. Sylvanus Thompson, at the Royal Victoria Hall. The construction and use of the vibrating armature, and the source of the energy expended in working the apparatus, were made quite clear to the audience; the subject being illustrated by a number of experiments.

Australia.—The electric lighting of the Adelaide Exhibition comprises 144 arc and 266 incandescence lamps. The former are worked by 11 Brush dynamos, 10 of which are of 8,000 and 1 of 6,000 watts. The incandescence lamps are worked by 3 Victoria dynamos of 8,000 watts each, an Edison-Hopkinson machine of 8,000 watts, and an Edison dynamo of 5,000 watts. The total length of the cables for conveying the current is 8 miles.

Electrical Tramways.—The paper on "the Bessbrook and Newry Tramway," by Dr. E. Hopkinson, recently read before the Institution of Civil Engineers, has just been issued by the Institution in pamphlet form. The paper is perhaps the most exhaustive that has been given on the subject of electrical tramways in England, and, with the discussion thereon, contains a vast amount of information of interest to all engaged in light or street tramway work.

Traction.—The new tramway at Ansonia, Conn., is expected to be ready immediately. It will have one 60 h.-p. motor to pull goods, and four 15 h.-p. motors to haul the passenger cars. It is claimed that this is one of the best equipped electric roads in America. The Ontario and San Antonio Heights road is well advanced. Here the third-rail system is adopted. The lines are laid with 30lb. steel rails. The running will commence with four cars and three motors.

The Electro-Harmonic Society.—The last smoking concert of the season 1887-1888 will take place at the usual *rendezvous* on Friday evening, April 6th. An innovation in entertainments of the kind will be made, a string quartette, performing works of Mozart and Haydn, taking the place of the usual glee party. Violin duets, which some decades since were so fashionable, but which are now rarely heard, will also be played, and the vocal element will be ably sustained by Messrs. Arthur Thompson and Robert Hilton and Master Humm.

The Defective Lewis Cable.—Arrangements have now been made for carrying on telegraph communication between the island of Lewis and the mainland by means of the cable across the Minch, which has for several days been in a defective state. Two clerks from the Inverness office have been sent to Poolewe—where the cable joins the mainland—and by tapping the wire there they have established a temporary telegraph station, from which the messages are retransmitted to their destination. A cable ship will, it is understood, be at once sent to repair the damage.

Electrical Quackery.—A circular with which one of our friends has obliged us, says *l'Electricien*, announces an important discovery made by Mme. V. L. According to this philanthropic inventor, invalids may in all cases be restored to health by the use of "*Dynamo-Electric Water*" applied as a lotion, or for fomentations, or in the form of a bath; and it will be found more efficacious than the most celebrated mineral waters. As our contemporary observes, there are not only big charlatans but little ones in the electrical field, without counting those in petticoats, like Mme. V. L.

Currents under Gaseous Pressure.—M. Cailletet whose name is so well known in connection with the liquefaction of gases, and who has recently devised an apparatus for heating substances by electricity under high gaseous pressure, has pointed out that a current which would ordinarily fuse a given wire or sheet of platinum produces only a temperature rising to dull redness when the gaseous pressure is sufficiently high. It has also been shown by the same experimenter that this phenomenon is due to convection, since the temperature is greatly augmented by surrounding the heated body by a glass test tube which prevents the movement of the gas.

Paris Theatres.—The lighting by electricity of the ill-fated Opera Comique was commenced on the 15th inst., a trial of the exterior lamps having been made during the two previous days. The installation at present comprises 503 incandescence lamps, exclusive of those which are now being supplied to that portion of the building which is

behind the footlights. The current is supplied from the machines established in the Chatelet by the *Société d'Eclairage Electrique*.—The electric lighting of the Odéon Theatre, carried out by the Edison Company, was inaugurated on the 20th inst. It comprises 1,200 incandescence lamps, worked by three dynamos each capable of maintaining 500 lamps.

Another Theatre Burned Down through Gas.—Another catastrophe, comparing in horror with that at the Paris Opéra Comique, is announced from Oporto. The Baquet Theatre in that town was completely destroyed by fire on the night of the 20th inst.; the conflagration being caused by a gas accident which occurred during the last act of the piece in representation. Unfortunately, there was a very full house at the time, and it is feared that nearly all the occupants of the upper gallery lost their lives. The number of persons ascertained by the police to be missing was given on Wednesday evening as forty; but the number of those who perished is, we regret to say, probably very much greater.

Electrical Images.—The phenomenon, first observed by M. Karsten, which occurs when, for instance, a piece of glass separates a sheet of tin foil and a coin, and the metals are connected to a frictional machine in action, is tolerably well known. A very perfect and delicate image of the face of the coin is obtained when the glass is breathed upon. In repeating this experiment, M. Tschechowitch made the curious observation that the image thus obtained may readily be fixed by slightly moistening the glass with a weak solution of stearine, oxide of zinc, or yellow oxide of mercury in benzine. It was also observed that a very distinct image was obtained by coating the glass in the first instance with a very slight layer of vaseline or of a fatty substance; the appearance of the coin is very satisfactorily reproduced on this layer.

American Testimony.—There is no doubt, says Mr. Johnson, President of the Lafayette-street Railway, but that electric motors will soon take the place of our "horse motors." The best field for the promoters of electric roads is new roads, as we who have horses know something of the cost of daily running, while all the statements that I have ever seen state the cost of horse-power away above what it is. The different electric motor companies do not guarantee anything as to daily cost, and you can't hold them down to an estimate for average days. Until they will meet this demand of the street car companies I think the "changing" will "make haste slowly." According to the testimony of the North Metropolitan Tramway Company, that Company has a guaranteed contract for electric traction at 4½d. per mile.

Incandescence Filaments.—An American contemporary points out that the filaments of high resistance lamps afford a good illustration of the effects of elasticity. Surrounded by a vacuum, so as to be free from the damping effects of the air, no object more sensitive to vibrations or shocks can be found. The least tremor of the wall to which the lamps are attached makes the loop vibrate for a long period. This only takes place when they are cold. When the current is passing and they become red or white hot, they are no longer so elastic, and cannot be made to vibrate as before. It would seem possible that a visual seismograph of extreme sensitiveness could be made on the general lines of an incandescent burner. It is probable that a filament could be obtained in this way more affected by external vibrations than is the most sensitive d now used.

Vibrating Strings.—Herr J. Puluj, of Vienna devised an extremely ingenious method of rendering v the form of a stretched string set in vibration. One extremities is attached to the prong of a tuning-fork, is kept in motion by an electro-magnet contact br and which gives a definite note, the pitch of which is fully determined. The vibrating string is lighted up vacuum tube connected with a Ruhmkorff coil, the r discharge through the tube being alterable at will, and this is made equal to or some aliquot multiple o number of vibrations made by the string, the latter is illumined when occupying some one definite position owing to the persistence of its image on the retina, it ap as if at rest. In this way the form assumed by the and the positions of the nodes and ventrical segmen rendered clearly visible.

Electrical Barometer.—*L'Electricien* gives a de tion of an electrical barometer devised by M. Renning which there is a cylinder, inscribed with the more c conventional indications: Much Rain, Rain, Change moved by clockwork which is brought into operati electric currents from the "dry pile" of Dr. Ga These currents, as most of our readers will unde without further description, affect the cylinder, th the intermediary of an electro-magnet, whenever contacts are established by the movement of the nee an aneroid barometer. It seems to us that M. Renn invention, supposing it to have preceded the ordinar arrangement, might have been greatly improve simplified by directly utilising the needle as a p This very negative praise would not apply, howe cases where it might be necessary to show the indi at a distance from the instrument.

The Steam Electro Magnet.—Many of our r like ourselves, may have been under the imp that—whatever be the explanation of the fact— of iron becomes magnetised, in some degree, w current of steam is caused to traverse with su velociety a tube of copper, wound helically upo core. The experimental result in question wa obtained, we understood, by M. Tommasi, and his was subsequently confirmed by M. Thouvenot. A pondent of *l'Electricien* now states that he has repeat experiment with an entirely negative result, even higher steam pressures than had been mentioned as sary. Messrs. Tommasi and Thouvenot have, unde circumstances, been requested to render assista explanation; and the Editor of the above-named p about to repeat the experiment for the satisfact those who are interested in the question.

Private Press Wires.—For some years pa proprietors of the *Manchester Evening News* have be ing to induce the Post Office authorities to grant th use of a private wire between Manchester and L This has been persistently refused until recently, but a the Post Office people have given way, and the 2 witnessed the commencement of a scheme which p to practically revolutionise the evening newspaper the United Kingdom. The whole of the Parlian intelligence and other matters will be sent throu private wire direct, instead of having to await the nience of the public service, and events of supreme imp to the community will be known and circulated

chester as quickly as in London itself. Only journalists can appreciate fully what this means, and how necessary it will probably be found for other provincial newspaper proprietors to follow suit; but even the outside public will be able to understand in a large measure the importance of the innovation.

The Brussels Hotel-de-Ville.—The work in connection with the electric lighting of this edifice is assuming an increased importance. M. Léon Gérard, who carried out the initial installation, has recently been entrusted with the lighting of the hall in which the meetings of the Communal Council take place. This hall, which is of great historical interest, is one of the grandest in the whole building; it is magnificently decorated in the Louis XV. style, and the ceiling is painted by Janssens. To the great moulded cornice of the ceiling are attached 100 16 candle-power lamps, which bring into brilliant relief the gilding with which every projecting point is ornamented. An extremely soft and rich effect is produced by this lighting of the ceiling. The meeting hall of the sections is illuminated by 72 16 c.-p. lamps, carried by three bronze lustres. The lighting of the hall intended for the operations of the militia is effected by two Pilsen arc lamps, each taking 12 amperes. The installation at present comprises 700 incandescence and two arc lamps. The original motive power having become insufficient, it is proposed to connect the Hotel de Ville mains with those belonging to the installation carried out by the same firm at the Laeken Gasworks, and employed for lighting the stage at the *Théâtre de la Monnaie*.

Barcelona Exhibition, 1888.—The Secretary of State for Foreign Affairs has communicated to the Society of Arts a despatch from Her Majesty's Ambassador at Madrid, reporting on the present state of the intended Exhibition at Barcelona, in which Sir Francis Clare-Ford refers to the condition of the Exhibition, and the rapid progress which is being made in the improvement of the City of Barcelona by the erection around the Exhibition of many fine buildings. Gardens are being laid out where before were unseemly pieces of waste ground. An aquarium is to be built on the sands, and commodious bathing houses and tents are to be erected; one of these is to be arranged for the special use of the Queen Regent. It is stated that there will be over 30,000 exhibitors, of whom only 80 are English; 3,500 square yards are assigned to the Barcelona Province alone, of which 3,000 have already been secured. The first batch of goods for the exhibition has arrived from Germany and Austria; and great efforts are being made to insure the success of the French portion of the exhibition. In the agricultural pavilion a space of 800 square yards has been assigned for French agricultural products. The ambassador expresses the opinion that the date for the opening of the exhibition will have to be postponed, as it cannot be ready much before the first week in May.

The Brussels Tramways.—From the following passages in the report of the Directors, read at their meeting on the 15th inst., it would appear that electric traction has not yet given results as satisfactory as those which were expected:—" Yielding to the wishes expressed, or rather, to the requests formally put forward, by an influential section of the shareholders at the general meeting of March 15, 1885, we have made some trials of electric traction. Up to the present the experiments have not fulfilled the expectations of those who promoted them. The working by electricity was commenced on April 17 by a car travelling between Rue Belliard and the Place Royale. A second car was appropriated to this service on May 8, and a third on September 19. These three cars are at present working at the Rue de la Loi. In 1887 the electric cars travelled over 54,987 kilometres and replaced 4,800 'horse-days.' We shall endeavour to obtain better results, especially from the point of view of the economic maintainance of the apparatus. Until we have succeeded in so doing, we do not propose to increase the number of electric cars which are at present running." The above meagre and insufficient statement as to kilometres and "horse-days" must be supplemented by other information, and more particularly by details as to cost of working, before the determination arrived at by the Directors can be rendered intelligible.

Dust on Electric Light Leads.—Mr. G. A. Nellis, writing to *The Electrical World*, says:—We have in our Allegheny County Station here in Pitsburgh a line of "direct" (continuous current) and a line of "alternating" wires side by side, both supplying lights of the same candle power and voltage. Both lines were put up at the same time, the lights started together, and they burn the same at all times. The alternating current wires are as clean as when we put them up; but the direct wires are as dirty as they could well be. There is no trouble whatever to distinguish the one from the other; there is such a contrast. Mr. Nellis also points out that the ceiling is blackened on both sides of the lead fastened to it, and that the accumulation of dust is more noticeable on the positive than on the negative wires. The facts, as stated, are of some interest, and we shall be glad to receive any details of further observations in relation to them. The theory advanced to explain them does not, however, appear to us a *vera causa*. It is that "magnetic whirls" are induced around the wire when a current of electricity is sent through it, and that the magnetism acts on the atmosphere, attracting the paramagnetic oxygen and repelling the diamagnetic nitrogen, and thus, in some manner, which is not explained, attracting some of the particles of dust and repelling others. We think that the phenomenon is much more probably due simply to electrostatic charge.

The Electric Light in France.—In our issue of the 2nd inst. the establishment of a central station for lighting the town of Grenade-sur-Garonne was mentioned. This installation would appear to be an admirable example of what can be done in a rough and ready way by local enterprise. *L'Electricien* observes in relation to it that it would be difficult to carry out such work in a more simple, *rustic* and economical manner. The motive power is supplied by a turbine erected on the river Save. This works a four-pole dynamo on the Parent and Kœrtel system, double wound, and giving a constant potential at a speed of 900 revolutions per minute. The public lighting comprises 90 street lamps and 16 electric candles, which are worked at the contract price of 4,000fr. per annum. The lamps supplied to subscribers are also worked under contract at the marvellously low price of 5 centimes per day per lamp of 10 c.-p. and 10 centimes per day per lamp of 16 c.-p.; the renewal of the lamps being, of course, at the expense of the subscribers.—At Perpignan, a company for the distribution of the electric light has just been established. It has already obtained the necessary authority for carrying the leads through the streets, and is carrying on negociations with the municipality in relation to the public lighting. The existing gas company regards this competition as a

very serious matter.—The municipality of Havre invites tenders for the establishment of a central distributing station in that city.

Royal Meteorological Society.—The exhibition which is ordinarily held during the present month by this Society was this year of a very interesting character, being devoted to appartus relating to the study of atmospheric electricity, which has been on view at the Institute of Civil Engineers during the three days ending on the 23rd inst. An extensive collection of electrometers and various forms of lightning conductors and protectors were shown. The collection of articles damaged by lightning attracted much attention, including as it did the clothing which was torn from the body of a man during the storm of June 8th, 1878. He was imprudently standing under a tree at the time of the occurrence. The lightning flash, after ripping his smock-frock from end to end, severed his leathern gaiters, tore the trousers into shreds, and finally split up each boot from ankle to toe. The man, we are informed, was not killed, but it is perhaps unnecessary to add that he has since entertained a very wholesome dread of thunderstorms. Various examples of the effects of lightning on trees are also to be seen, with pieces of wood and bark actually severed in storms of recent years. There is also a set of objects designed to upset the very popular idea as to the falling of thunderbolts. In one case it is shown that the alleged thunderbolt was in reality an old cannon-ball, while in another instance it is asserted that the dread visitant which had created so much alarm was nothing more than a piece of coal. The photographs of lightning flashes are both numerous and excellent, and the exhibits in this class should certainly be inspected by painters, whose representations of the appearance of the discharge are invariably of a conventional character.

The Electric Light at Southampton.—The garbage and town refuse of Southampton is largely disposed of in a "destructor." This means the generation of heat, which is turned to account in raising steam; and of this circumstance advantage was recently taken by the borough surveyor (Mr. W. B. G. Bennett) to carry out an interesting experiment in electric lighting. The dynamo used for the production of the electric light in connection with the Jubilee illuminations being still in Southampton, the borough surveyor obtained permission for its temporary use. The process by which the results are attained is as follows:—The town refuse provides the destructor with fuel to feed the furnaces; the heat generates steam in the boilers; the steam pressure propels the engine, and the engine drives the dynamo which produces the electric current. So that the power by which the lighting is obtained practically costs nothing for fuel. The current is supplied direct from the dynamo; and all the lights are under perfect control by the use of a separate switch for each light. At present the circuit supplies 12 glow lamps and four arc lights, each of the latter being equal to 3,000 candle-power. The maximum capacity of the dynamo will furnish light for 10 of the 3,000-candle arc lights, or 30 of 1,000 candle-power, or 250 glow lamps. By the present arrangement one central arc light illuminates the whole of the Corporation Wharf of three acres, while light is provided for the office, the wheelwrights' shop, the engine-house, and the destructor. Beyond the outlay for the dynamo and the nesessary arrangements, there is said to be practically no expense for the production of the electric light, except that involved in supervision and attendance. The cost is stated to be considerably less than that of the present gas lighting.

Milan (Porte Simplon) Terminus.—Some interesting information in relation to the lighting of this important railway terminus and shunting station has been recently published by M. Cosmann, engineer to the *Chemin de fer du Nord*. The terminus was in the first place lighted by petroleum; but the result obtained was insufficient, especially during the fogs prevalent in Lombardy. A plan of lighting by means of improved gas burners was abandoned by reason of the expense. A first trial of electric lighting which was made in 1884 having given favourable results, it was definitively decided to adopt this system, which has been in successful operation for the last three years. The illumination of the line junctions is obtained by means of three arc lights mounted on iron masts; whilst the shunting is carried out by means of three lights supplied with lenses. Two of the three masts are 12½ metres high, and carry lights equivalent to 990 carcel burners, and each consuming 33 amperes and 50 volts. The third mast, 9 metres high, carries a lamp of 528 carcels, taking 20 amperes and 50 volts. The three arc lamps for the projected light are each of 990 carcels; the lenses with which they are supplied being of the Balestrini system. The motive power is supplied by two steam engines each of 35 h.-p., one of these only being generally in use. The dynamos, six in number, are continuous-current machines of the Siemens type. The expenses of working the installation, from July 7, 1885, to June 30, 1886, are summed up as follows:—

		Francs.
Motive Power		14,940
Staff		12,140
Carbons for lamps		5,843
Belting, &c.		3,674
Gas lighting of engine shed		870
		37,467
Total expense of establishment	141,944fr.	
Representing in interest and sinking fund at 5 per cent.		14,194
Or for 6 lights during 3,824 hours, and a total lighting power of 5,478 carcels		51,661

The expense is therefore 2·59fr. per lamp hour, or 0·00025fr. per carcel hour. The advantage of being able to carry out the work within the station with the same security during the night as during the day is one that is fully appreciated.

American Tramway Notes.—The Observatory Hill Road, with electric traction, is now in successful operation. The cars, with fifty passengers, climb an up-grade of nearly 1 in 10 at six miles an hour, and attain a speed of fifteen miles an hour on the level.—The Woonsocket Street Railway Company, who made an eight weeks' trial of a Thomson-Houston motor last year, have expressed themselves satisfied with the results attained; and it is expected that they will equip their cars with about ten motors in the spring.—A trial of the Julien-Brush electric car was recently made in St. Louis. The car was in active operation for five hours, and during that time it made twelve trips over the Washington-avenue line. Various speeds were tried, and the grades were experimented on, with satisfactory results. Most of the patrons of the line took advantage of the experiments, and got on the car, which was thus filled compactly at every trip. As Mr. Baumhoff expressed it, "A bushel of nickels was taken in." The car shed is on Twenty-second-street and Washington-avenue, and the charging current, which is supplied by the Brush electric light

works, is transmitted to the shed by wire from Seventh and Walnut streets. The test is said to have given satisfaction, and others have since been made with similar results. The Julien Company complain of the poor quality of the steel driving chains made in America compared with those made in England. They are now importing their chains, but are striving to obtain others of equal quality in the home market.—For some months the Sprague Electric Railway and Power Company have been quietly experimenting with a new storage battery of their own design, and they believe that they have arrived at results much more satisfactory than any hitherto attained. The details of the battery are not yet made public, but we understand that President Whitney, of the West End Street Railway Company, Boston, has decided not to introduce the cable system, nor make any other change in the motive-power in use by that Company, until the Sprague Company has completed its experiments upon it, and shown whether it is a good thing or not.—Mr. Thomas, professor of physics of the Ohio State University, has been conducting a series of experimental tests of the Short overhead system of electric railways in operation at Columbus, Ohio, and is said to be surprised at the degree of efficiency obtained.

Overhead Wires.—A conference of the delegates appointed by various metropolitan vestries and district boards of works was held Thursday, March 15, at the Lambeth Vestry Hall, Kennington (Mr. F. H. Fowler in the chair), when delegates were present from the following vestries and district boards :—Vestries : Bethnal Green; St. Giles's, Camberwell; Clerkenwell; Kensington; Lambeth; St. Martin's-in-the-Fields; Newington; St. George's, Southwark; St. Leonard's, Shoreditch; and St. James's, Westminster. District Boards: Greenwich, Hackney, St. Saviour's and Wandsworth. The following resolutions were unanimously carried :—1. That, in the opinion of this meeting of delegates from the various metropolitan vestries and district boards of works, it is desirable, in the interest of the inhabitants of the metropolis, that, as a general principle, all telephone, telegraph, and electric lighting wires within the metropolitan area should be placed underground. 2. That the control of the construction and maintenance of all telephone, telegraph, and electric lighting wires in the parishes mentioned in Shedules A and B to the Metropolis Local Management Act, 1855, should, whether within 15ft. of the surface of the road or not, vest in and be under the direction of the vestry or district board of the parish or district in which such telephone and telegraph wires are situate. 3. That in order to prevent any separate vestry or district board refusing, arbitrarily the passage of through wires across their parish, to the detriment of other parishes, an appeal should be allowed to the Metropolitan Board of Works similar to that sanctioned by Section 211 of the Metropolis Local Management Act, with reference to the orders or acts of the vestry or board in relation to buildings, sewers, &c. 4. That, considering the serious invasion, not only of the public, but also of private rights proposed by the Bill of the United Telephone Company, the various vestries and district boards be recommended to adopt the foregoing resolutions, and to oppose the Bill, with the view to have the principles embodied in such resolutions incorporated in the Bill, and such other amendments as are detailed in the petition of the Metropolitan Board of Works against the Bill. 5. That copies of the foregoing resolutions be sent to all the vestries and district boards of the metropolis and to the Metropolitan Board of Works. 6. That each vestry and district board be asked to petition Parliament against the Bill, and to oppose it through the local members of Parliament.

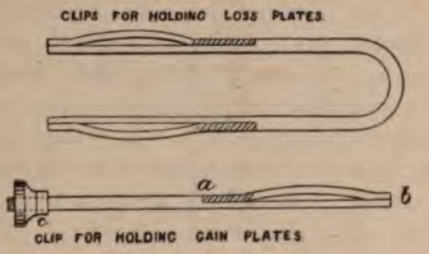
Alkalies and the E.M.F. of Zinc.—In a recent paper, M. J. H. Koosen discusses the property of alkalies increasing the E.M.F. of zinc. For the following extract from this paper we are indebted to the Chemical Society's *Journal* :—Grove, Joule, Poggendorff, and others have observed the increased E.M.F. obtained by substituting aqueous potash or soda for the dilute acid in a cell. The author states that, according to his researches, the alkali, say, potassium hydroxide, has a fourfold action: (1) it breaks up into potassium and oxygen; (2) potassium replaces zinc in its electrical action—for instance, in a Daniell's cell potassium sulphate is formed in place of zinc sulphate, as the copper is deposited; (3) the zinc is oxidised by the oxygen of the potash; (4) the resulting zinc oxide is dissolved by the aqueous potash. (1) Diminishes the E.M.F., whilst (2) and (3) increase it; (4) may possibly slightly increase it, but it would be desirable to have positive evidence on this point. If the external resistance of a cell is very great, almost the whole heat of combination will be developed in the external circuit. Let the E.M.F. of a Daniell's cell be taken as the unit of E.M.F., and let the unit of heat be the amount generated in a Daniell's cell by the decomposition of n grams of zinc, where n is the atomic weight of that metal. Then from Thomsen's determinations, the E.M.F. of a Daniell's cell is given by the equation $ZnSO_4(248) - CuSO_4(198) = 50 = 1$ Daniell; and with potash substituted for dilute sulphuric acid $K_2SO_4(337) + 2ZnOH_2O(166) - 2KHO232 - CuSO_4(198) = 73 = 1{\cdot}46$ Daniell. For the author's zinc-bromide-platinum cell, $ZnBr_2(91) = 1{\cdot}82$ Daniell. The result thus theoretically obtained in the case of these and a few other simple cells considered by the author agree closely with experimental determinations. The heat of combustion of zinc oxide and potassium is not taken into account, as it is certainly not more than 2 per cent. of that due to the decomposition of zinc in a Daniell's cell, and according to Favre and Silbermann it would seem that this chemical action is merely local, and does not contribute to the electrical energy. Practically, the author finds that a Daniell's cell with a solution of potassium hydroxide is very satisfactory for giving continuous currents through a high resistance, and sodium hydroxide gives still better results, as sodium sulphate, being more soluble, does not so readily crystallise on the porous cell. It is very important to prevent interdiffusion of the fluids as far as possible, and for this purpose the author uses a double porous cell, having the intermediate space filled with a solution of potassium and sodium sulphates respectively, with a small admixture of sulphuric acid to diminish the resistance. Cells of this kind have been kept joined up through a resistance of 20 or 30 ohms for weeks together without any perceptible diminution in the E.M.F. The alkaline solution must not be too dilute, or the zinc will soon become coated with oxide. The author states that his zinc-bromine-platinum cell is still better for giving a continuous current through a high resistance. It requires no porous cell, has a high E.M.F., and has been kept in continuous action for months without any change in the E.M.F.—in fact, until one or other of the elements was completely decomposed. The only precaution necessary is to cover the bromine with a layer of petroleum, which completely prevents all evaporation and smell.

THE ELECTROLYSIS OF COPPER SULPHATE IN STANDARDISING ELECTRICAL INSTRUMENTS.*

BY A. W. MEIKLE (THOMSON EXPERIMENTAL SCHOLAR).

Owing to the great increase in the use of electricity in recent years, and the consequent importance of having accurate measuring instruments, it is necessary that electricians should have some accurate means whereby they may have their standard instruments readily and cheaply checked from time to time. Much might be said for a national recognition of this fact by the establishment of a system of electrical standards, just as we now have national standards of length, weight, &c., but such a subject is beyond the province of this paper, in which I propose to give a description of the electrolysis of copper sulphate, which has been employed for standardising purposes in the Physical Laboratory of Glasgow University for the last two years with the most satisfactory results.

FIG. I.



A paper communicated by Mr. Thomas Gray to the *Philosophical Magazine* for November, 1886, dealt with the question of the reliableness of copper electrolysis as compared with silver. The conclusion drawn from the investigation described in that paper was, that while silver in the hands of a trained experimenter left nothing to be desired in point of accuracy, still it is open to the objection that it is very costly where large currents are used, and requires great care in making the experiments. Copper, on the other hand, has the advantage of simplicity in manipulation, and where attention is given to a few necessary precautions great accuracy can be obtained. As an example of the difficulties in the use of silver I may mention that the deposit which is always crystaline in form, requires careful handling in order to prevent loss in drying or weighing, and in order to get it thoroughly adherent to the plate the area of the cathode or gain plate should never be less than 200 or more than 400 sq. cms. per ampere. With copper the deposit for areas exceeding 20 sq. cms. per ampere is thoroughly adherent to the plate, of which,

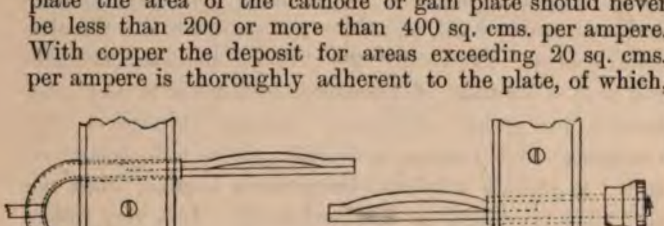


FIG. 2.

indeed, it forms an integral part. Thus in making an electrolysis of copper sulphate for 100 amperes, a current density of 1 ampere to 50 sq. cms. would give excellent results, and the total area of gain plates would only be 5,000 sq. cms., while were silver used the area would require to be from 20,000 to 30,000 sq. cms. One disadvantage which copper has is its readiness to oxidise when exposed to the air, more especially when being taken out of the sulphate of copper solution, but if the mode of cleaning and drying the plates, both before and after electrolytic action, which is described in this paper, be employed, this difficulty is easily overcome. I have kept plates for a week after being treated in this manner without being able to observe any change of weight as indicated by a chemical balance, which is sensitive to $\frac{1}{10000}$ of a gramme.

* Paper read before the Physical Society of Glasgow University, January 27th.

Another point, which has to be taken into account, is the fact that the plates lose weight in the solution at a rate varying with the area they expose to the action of the acid which is contained in all electrolytic solutions of sulphate of copper capable of giving reliable results. This question was gone into very fully by Mr. Gray about two years ago, and the results are given in his paper on electrolysis which is referred to above. It has again been gone into when making some experiments on the effect of temperature on the loss of weight of the plates in the solution. The results of these experiments, which were made by passing the current through ten cells in series,

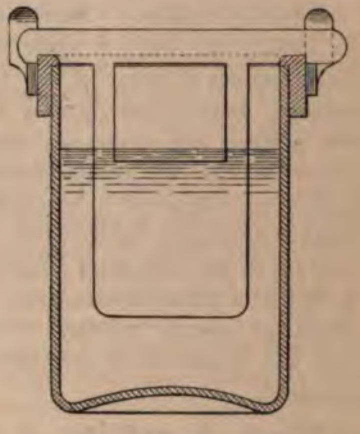


FIG. 3.

each of which had a different area of plate, is to confirm the experiments made by Mr. Gray, and to show that the amount of variation from the true electro-chemical equivalent of copper due to differences of current density can be allowed for with great accuracy. Before describing particularly the results of these experiments, it may be well to refer briefly to the apparatus used.

Electrolytic Cells.—The electrolytic cell found most convenient for small currents consists of a round glass jar nearly filled with sulphate of copper solution, into which three vertical plates with their surfaces parallel and about 15mm. apart are held by means of rigid platenoid clips. The two outside clips are joined together and the plates held in them are the anodes or loss plates (*see* Fig. 1). Two loss plates are always put into each cell, one on each side of the gain plate, so that the gain plate may receive a

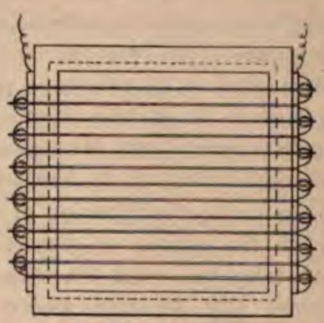


FIG. 4.

FIG. 5.

uniform deposit on each side. The centre clip which is well insulated from the two others holds the cathode or gain plate. The clips for holding the gain plates are formed of straight pieces of No. 6 platinoid wire about six inches long, a portion of which, about four inches long, is filed flat, and on to this another piece of platenoid, bent so as to form a powerful spring is soldered at *a*, so that the two ends of the pieces form a firm contact at *b* (Fig. 1). A binding screw for fixing on the electrode is screwed on to the other end at *c*. Several of the clips so formed are firmly clamped on to a rectangular wooden frame by screwing a strip of wood down on the top of them, the portion of the clip between the wood being well insulated by being covered by a piece of thick indiarubber tube.

The clips for holding the loss plates are formed in the same manner as the gain plates, but are made in pairs by bending a piece of No. 6 platinoid wire into the shape of a U, with about three centimetres between its ends, and then

soldering on the springs as already described. These clips are insulated and fixed on to the frame on the opposite side from the single clips, so that the end of the latter comes just between the two ends of the former as shown in Fig. 2. A flexible covered copper wire, of convenient length to enable the cells to be joined in series if desired, is permanently soldered on to the bend of the double clips. This mode of placing several sets of clips on a wooden stand is found very convenient, as the plates can readily be adjusted in their position, or taken out without disturbing any of the other arrangements. This form of clip suits very well for currents up to about 15 amperes, by joining the cells in series or parallel as may be necessary. In using electrolysis for small currents up to 2 amperes, it is advisable to use two or even three cells in series, as with small deposits a check is thus obtained on the weighings or any defect in an individual cell. With currents from 3 to 15 amperes, I prefer still to use this form of clip, and a sufficient number of cells in parallel, each having gain plates of about 130 sq. cms. in area, so that the plates, owing to their comparative lightness, may be weighed on the chemical balance—the additional number of weighings being more than compensated for by the additional accuracy obtained.

For currents, such as are used in standardising a deca or hecto ampere balance, owing to the large amount of copper deposited, such delicate weighing is not necessary, and a balance sensitive to about 2 millegrammes may be used; but even were an error of 5 millegrammes made in weighing the plates of an electrolysis for 50 amperes

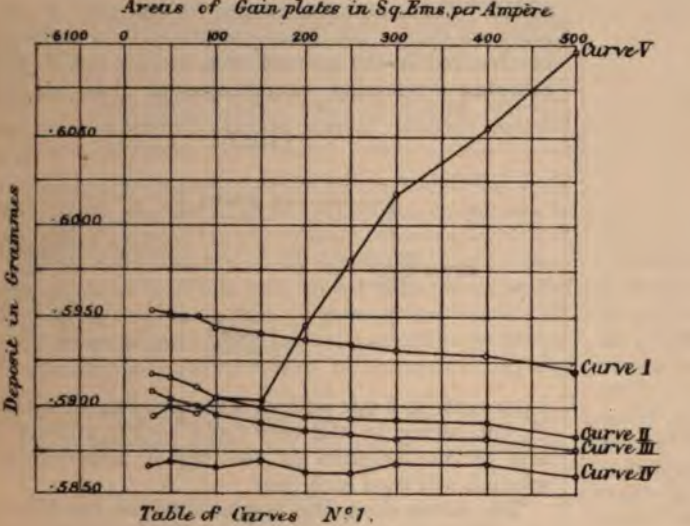


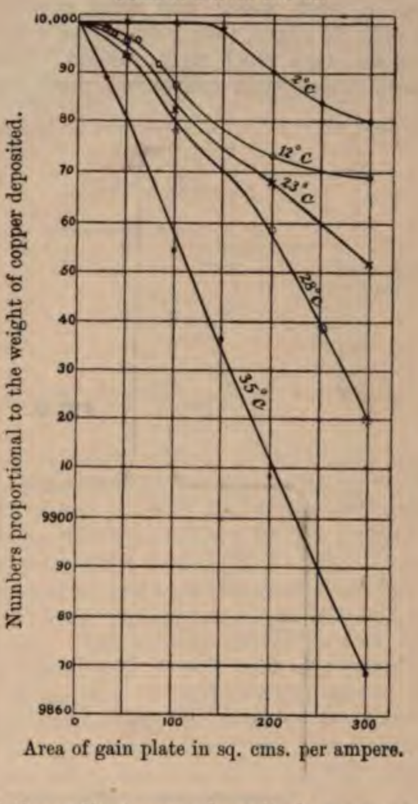
Table of Curves No. 1.

continued for one hour, the error would only amount to about $\frac{1}{100}$ per cent. For high currents, such as these, a large earthenware cell is used, which is shown in Figs. 3 and 4. A wooden frame is fitted on to the top of this cell, and on two opposite sides of this frame and well insulated from each other, two copper bars are screwed, one having 10 and the other 11 spring contact clips of the form shown in Fig. 5. The plates for this cell are made of sheets of copper each of which has a rigid strip of copper soldered to its top edge and projecting about two inches on each side of the plate. On putting the plates into the cell one end of this strip fits into a clip and the other rests in a vulcanite notch on the other side of the cell. Each of the plates when in position exposes a surface of 1,100 sq. cms. to electrolytic action, so by putting in the proper number of plates the cell can be used for currents up to 200 amperes. The plates and clips are so arranged that one gain plate comes between two loss plates, and the latter always exceed the former in number by one. As the plates, when all are put in, are very close together two glass tubes bent so as to form U's, and long enough to reach to the bottom of the cell, are hung over each loss plate to prevent any danger of the plates touching. Two flexible electrodes suitable for dipping into mercury cups are attached to the bars carrying the clips.

The Solution for the Electrolytic Cells.—The solution used is made by dissolving commercial copper sulphate in pure water as it comes from the Glasgow Corporation's water pipes until a density of from 1·15 to 1·18 is obtained, and then adding one per cent. of free sulphuric acid. In all the experiments mentioned in this paper the solution used has been of a uniform density of 1·175, but it has been found that a variation in density from 1·1 to 2 makes no difference in the nature or quantity of the deposit. With solutions made up as described perfecty accordant results have invariably been obtained. The solution should not be used too often, as the acid is after a time exhausted by action with the plates, and it has been found from experience that unless the solution is decidedly acid the plates are oxidized in the solution and very irregular results are obtained, which are quite valueless for accurate standardising. The table of curves (No. I.) shows very clearly the difference between results obtained from solutions which have free acid, and those which have not.

The five curves are taken from experiments made with ten cells in series and different areas of gain plate in each. The abscissæ are areas of gain plates in square centimetres

Table of Curves No. II.



per ampere, and the ordinates are deposits in grammes. It will at once be observed that the curves I., II., and III. are exactly similar in form. Curve I. is the mean of about twelve experiments made with free acid in the solution. Curves II. and III. are from two single experiments also with about 1 per cent. of free acid in the solution. Curve IV. is taken from an experiment made with solution which had been used too often, and the results are irregular, owing to oxidation of the plates in the solution. Curve V. shows the results obtained from a solution in which some copper oxide had been dissolved so as to withdraw all the free acid. The gain plates were found to be very much oxidised when taken out of the solution, and had a dark brown colour instead of the bright metallic surface which they have when taken from a solution which contains acid.

Preparation of Plates.—The gain plates used are made from ordinary high conductivity sheet copper about $\frac{3}{10}$ of a millemetre in thickness. For the smaller cells they are cut in the shape shown in Fig. 6, as this form of plate, owing to the flexible tongue, is very easy to adjust in its position, and when in use the whole plate is immersed in the solution except the narrow tongue necessary to hold the plate between the contact clips, thus leaving a very small area exposed to any possible oxidation by the atmosphere. This form of plate has also the advantage that the area exposed to electrolytic action can be got at once, or may be permanently stamped upon the tongue, and the proper equivalent for the current

density can be taken without having to measure the area covered by the deposit. The edges of the plate are all smoothed, and the corners rounded off, as the deposit is apt to form on any rough edges, especially if a high current density is being used, or if the current is being run for a long time. When this has taken place the plates, owing to the roughness of the surface, are not so readily dried, and the risk of oxidation is increased, as is also the risk of losing part of the deposit should the plate accidentally strike against any object. The surface of the plates is burnished with fine glass paper until perfectly bright and smooth, then rubbed with a piece of clean cloth, and finally wiped gently with a piece of silk to remove any shreds, after which they are ready for weighing. Another plan, which has been successfully employed, is to polish the plate with silver sand and water, to which a few drops of sulphuric acid was sometimes added. The plates are then washed in clean water to remove the sand, and placed in a vessel containing pure water with a little sulphuric acid in it to remove any oxide which may have formed during the washing. From this they are taken one at a time, quickly dipped in fresh water, and dried immediately on clean white blotting paper, then held before a fire to remove any trace of moisture which might remain. The method which has been found most convenient, however, is to place a

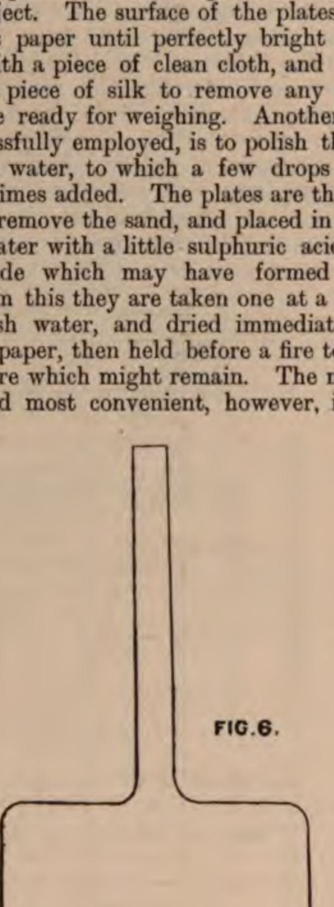


FIG.6.

sheet of No. 1 glass paper on a wooden roller and spin it in a turning lathe, holding the plate against it by a pad. When the plates have been burnished by this method, the sand paper, which is only held on the roller by two springs, is removed, and a piece of rough cloth put on instead. On this cloth the plates receive a final polish to remove grains of sand, then wiped with a piece of silk as in the first method, after which they are ready for weighing. Care should be taken never to touch with the fingers the portion of the plate intended for immersion in the cell, as by so doing the surface is spoiled for a deposit, and the mark of the finger is seen distinctly after the electrolytic action.

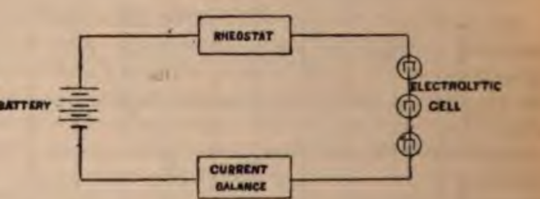
Loss plates are also made from high conductivity copper, but from a thicker sheet so that they may last for some time. No great trouble need be taken with them, except to see that they are not put into the liquid when badly oxidised, in which case the free acid in the solution unites with the oxide on the plate, and the solution suffers in consequence, as I have already explained. For this reason, too, the loss plates should never be left in the solution when not in use, but should be taken out and placed in water with a few drops of $H_2\ SO_4$ added, or, if they are not likely to be required again for some time, they should be dried and put away.

Size of Plates.—Loss plates should never have an area of less than 40 sq. cms. per ampere. If the area is much less than that, the resistance of the cell becomes high and variable owing to the formation of copper oxide on the plate, and if it be made very small, gas is given off at its surface, making it impossible to keep the current steady, and giving a result of no value for accurate standardising. The gain plates should never expose a surface of less than 20 sq. cms. per ampere. When too high a current density is used, the deposit is not so adherent to the plate, and a portion may be lost in washing and drying. It is always best to use an area of from 50 to 100 sq. cms. per ampere, using the larger area for currents which are intended to run for some time. By doing so any little roughness round the edges is avoided, and in consequence the plates are easier to dry.

As already mentioned at the beginning of the paper, the amount of copper deposited by a given current varies with the area of the plate exposed to the corrosive influence of the free acid in the solution of copper sulphate. This variation is not the same as it would be were no current running, in reality it is less, from which it would seem that the current exercised some protecting power. This subject has been very fully investigated in the Physical Laboratory, as also the effect of temperature on the rate of loss, and the results of the experiments are shown in the table of curves No. II., and the two tables of numbers which I shall speak of presently.

The experiments were made with ten cells in series, all carefully insulated from each other, and each cell having a different area of gain plate, the extreme range being from about 30 to 500 sq. cms. per ampere. The solution used in all cases was 1·17 in density with 1 per cent. of $H_2\ SO_4$ added. From former experiments described in Mr. Gray's paper on electrolysis before mentioned, no difference could be observed in the amount or appearance of deposits from solutions containing percentages of acid varying from

FIG.7



$\frac{1}{2}$ per cent. to 5 per cent. at a temperature of about 12deg. C., but owing to the very rapid consumption of the free acid in the solution at the higher temperatures, fresh solution was used each time.

The curves show the results obtained for different areas of cathode or gain plate, and each curve is for a different temperature between 2deg. C. and 35deg. C. It will be observed that they all converge rapidly towards the point of crossing, which shows that the same deposit would be had at all temperatures were it only possible to use a small enough area of gain plate. The curves were produced to cross the line of ordinates, and the point of crossing was taken as 10,000 and the other points reduced to correspond so as render percentage corrections easy for different current densities. The ordinates are therefore numbers proportional to the weight of copper deposited in grammes, while the abscissæ are areas of gain plate in square centimetres per ampere.

The curve for 2deg. C. is the mean of three experiments, which were in very close agreement. It is rather curious that for a range of current density almost up to 130 sq. cms. per ampere, there is no effect made by variations in the area of gain plates, but the same tendency is shown in the curves for 12deg. C., 23deg. C., and 28deg. C., although to a much smaller extent. The curve for 12deg. C. is the mean of a large number of experiments which were in very good agreement among themselves. It is the same curve which is shown as the mean curve in the first table, but on a different scale. The effect of temperature from 16deg. to 15deg. C., which is about the ordinary range of temperature in the Physical Laboratory of Glasgow University, is very small and may be neglected. Indeed, with a gain plate of 50 sq. cms. per ampere, the total variation in the corrected equivalents for 12deg. and 28deg. C. is only about $\frac{1}{16}$ per cent The curves for 23deg. C. and

. C. are two single experiments, while the curve for . C. is the mean of two experiments, which were in agreement with each other. A glance at the curves show how important the question of temperature ies at the high points. In countries where 28deg. 35deg. C. were normal temperatures a very careful ance would require to be made for any variation. No. 1 gives the numbers from which the second of curves is taken, and table No. 2 gives the corrected ochemical equivalents as calculated from these numbers fferent current densities from 1 ampere to 50 sq. cms. 1 ampere to 300 sq. cms.

TABLE I.

of cathode are centi- per ampere current.	Temperature, 2° C.	Temperature, 12° C.	Temperature, 23° C.	Temperature, 28° C.	Temperature, 35° C.
50	10,000	9996·4	9995	9993·5	9980·5
100	10,000	9987	9983	9979·5	9958
150	9998	9979·5	9974	9969·6	9935
200	9990	9973	9966·6	9957·5	9912
250	9984	9970	9959·5	9939·3	9890
300	9980	9968·5	9952	9920	9868·5
400	—	9961			
500	–	9949			

TABLE II.

of cathode are centi- per ampere current.	Temperature, 2° C.	Temperature, 12° C.	Temperature, 23° C.	Temperature, 28° C.	Temperature, 35° C.
50	·0003288	·0003287	·0003286	·0003286	·0003282
100	·0003288	·0003284	·0003283	·0003281	·0003274
150	·0003287	·0003281	·0003280	·0003278	·0003267
200	·0003285	·0003279	·0003277	·0003274	·0003259
250	·0003283	·0003278	·0003275	·0003268	·0003252
300	·0003282	·0003278	·0003272	·0003262	·0003245

ndardising Arrangements.—The arrangements for stan- ing consist, as shown in the diagrams, in joining in a constant battery, the instrument to be standardised, ectrolytic cells, and a variable resistance. Care should s be taken to join the instrument directly on to the olytic cells, and have that portion of the circuit well ted so as to be sure that the instrument is recording act amount of current which is going through the

simplest form of arrangement is shown in Fig. 7, suitable for currents up to 10 amperes. The variable

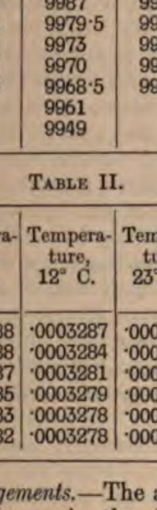
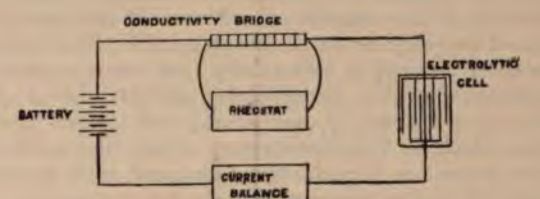


FIG. 8.

ance used in this case is one of Sir William Thomson's ats. For currents up to 1 ampere a high resistance at of platinoid wire is used, and for currents above point a large rheostat of stranded copper wire—the ial of the battery being first adjusted to suit the l case. With large currents beyond the carrying of any rheostat a conductivity bridge is put in circuit e purpose of varying the current. This bridge con- of a number of platinoid U's of sufficient length heat much with any current which the potential of the battery can send through them. By dipping the two ends of these U's in two parallel mercury troughs, any desired conductivity can be put into the circuit. Fig. 8 shows two of the large bridges, one of which is standing in the mercury troughs, while the other is standing on the insulated sides. The large bridges are kept apart by wooden distance pieces, as shown in the figure, while the small ones are supported on strips of wood through their whole length, and are fitted with thick copper terminal pieces. The copper rheostat before mentioned is joined in parallel to this bridge, and the whole arrangement, as shown in Fig. 9, simply takes the place of the rheostat in the former arrangement. We have found this last arrangement very useful for standardising instruments, as, with the battery power at our disposal, any current up to 500 amperes can be had by continuous steps. The apparatus being arranged as stated above, trial plates of the same area as the gain plates to be used are put into the electrolytic cell, and the current is adjusted to the required reading on the instrument. The circuit is then broken, the trial plates are replaced by the cleaned and weighed gain plates, and current is again made—the exact second being noted on an accurate timekeeper. The instrument should be found very nearly to record the desired reading, and should at once be adjusted by turning the rheostat, and by that means be kept steady during the experiment. Any error arising from the current not being at the proper strength on starting is very small. As a rule the current,

FIG. 9.



when previously adjusted as above, is, practically speaking, exactly correct when made for the standardising, but should it chance to be even so much as 5 per cent. wrong, an amount which with the precautions taken is entirely out of the question, it can easily be set right in at most 10 seconds, with apparatus such as has been described, and the whole error on an experiment lasting for one hour would only be about $\frac{1}{140}$ per cent. The current should be run until the amount of the deposit will be such that any possible error in weighing or in starting or stopping the current is, practically speaking, illiminated. In breaking the current the exact second is again noted, and the plates quickly removed from the clips, and placed in a glass vessel containing pure water with a few drops of H_2SO_4 added to prevent oxidation. From this they are taken one at a time, dipped in pure water, then dried and weighed, as before described in the process of cleaning with silver sand. The jaws of the clip are always opened before putting in or taking out the plates, so that there will be no error due to loss of weight by the friction of the plate with the spring contacts. The zero of the instrument is always carefully noted before and after the experiment.

STANDARDISINGS OF SIR WILLIAM THOMSON'S STANDARD CURRENT BALANCES.

As showing the degree of accuracy which can be obtained by the electrolysis of copper sulphate, I shall briefly give the results obtained from the standardisings of Sir William Thomson's standard current balances, the constants for which have been determined by the methods I have described. There are in the Physical Laboratory at the present time seven of these balances, whose measuring range is as follows:—

1. Hectro-ampere Balance, range from 20 to 500 amps.
2. Deca ,, ,, ,, ,, 4 to 100 ,,
3. Ampere ,, ,, ,, 1 to 25 ,,
4. Deci-Ampere Balance (*a*) range from 2 to 50 deci-amperes.
5. ,, ,, ,, (*b*) ,, ,, 1 ,, 25 ,, ,,
6. Centi-Ampere Balance (*a*) ,, ,, 2 ,, 50 centi-amperes.
7. ,, ,, ,, (*b*) ,, ,, 1 ,, 25 ,, ,,

(1) The constant of the Hecto was first found by electrolysis, and they were calculated from the result of the experiments. On being again checked by electrolysis on December 2nd, 1886, with its adjusted weights instead of 100 amperes as indicated by the instrument, the mean of two experiments gave a current value of 99·996 amperes.

(2) The Deca ampere balance was standardised by direct comparison with the Hecto, and on being checked by electrolysis on February 15th, 1887, a result of 49·978 amperes was obtained against a current of 50 amperes read on the instrument. The latest comparison still shows the instrument to be in perfect agreement with the Hecto. It has also been twice standardised by electrolysis at intervals of 5 months which gave results respectively of $\frac{1}{25}$ per cent. and $\frac{1}{33}$ per cent. too low.

(3) The constant of the ampere balance was determined by electrolysis, and on afterwards being compared with the Deca it showed a variation from that instrument of $\frac{1}{60}$ per cent.

(4) The constant of deci-ampere balance (*a*) was twice determined by electrolysis, which gave a difference of $\frac{1}{600}$ per cent between the two standardisings. Its weights were taken by calculation from the result of these experiments, and on being again checked by electrolysis the result howed $\frac{1}{80}$ per cent. too large on a current of 4 amperes as ead on the balance.

(5) Deci-ampere balance (*b*) was standardised by direct comparison with centi-ampere balance (*b*), and on being afterwards compared with deci-ampere balance (*a*) showed a variation from that instrument of less than $\frac{1}{100}$ per cent.

(6) The weights for centi-ampere balance (*a*) were determined by direct comparison with an old and now disused form of deci-ampere meter in June, 1887. Since that date it has been checked at intervals by four separate electrolysis experiments, which gave results respectively of $\frac{1}{14}$ per cent., $\frac{1}{14}$ per cent., $\frac{1}{17}$ per cent., and $\frac{1}{19}$ per cent. too large, which is very satisfactory when the small weight of the deposit is considered. Compared with deci-ampere balance (*b*) this instrument is in absolute agreement.

(7) The constant of centi-ampere balance (*b*) was determined by direct comparison with centi-ampere balance (*a*), from which, though comparisons have been made from time to time for the last six months, no variation whatever can be observed.

We have thus a chain of instruments measuring from one centi-ampere to 500 amperes, which are, practically speaking, in absolute agreement among themselves, and whose constants have been determined separately, and in many cases by different observers, by the process of electrolysis of copper sulphate described in this paper. This fact not only proves the constancy and accuracy of the instruments, but also establishes beyond a doubt the great value of the method of standardising, and that it is equally applicable to currents of all magnitudes.

ON THE COST OF CENTRAL STATION LIGHTING.

BY R. E. CROMPTON.

[The following article, referred to by Mr. Crompton in our correspondence columns last week, is taken from our excellent contemporary, *Industries*.]

An article under the above heading appeared in *Industries*, page 598, Vol. III., and it professed to deal with the comparative costs of distributing electricity by the three kinds of transformers now available, viz.: (1) accumulators used as transformers; (2) what Sir William Thomson calls "step down" dynamos used as transformers; (3) the well known alternating transformer system as used on the Grosvenor Gallery installation, and also by Westinghouse and others. In that article a great deal was said as to the great advantages, in point of cheapness, of the system I have placed third in order; and I will now proceed to show how the conclusions arrived at in that article may be considerably modified in favour of the accumulator transformer system, if the latter be treated in a somewhat different manner to that proposed by the writer of the article. I think he put this system in a false position by going too far in the direction of reducing current and increasing the E.M.F. No one will doubt that in a large number, in fact in the majority of cases, the generating station can be placed at a distance not exceeding one mile from the nearest part of the district requiring electricity for lighting or motive power purposes; and I propose to show that in these cases, when battery transformers—or what I shall briefly call the B.T. system—is used, the cost of the plant will only slightly, if at all, exceed that for an equivalent supply from alternating transformers—which, for convenience, I shall call the A.T. system. I prefer not to compare what might be done, but what has been actually and successfully done in the way of transforming by batteries with what has been done by alternating transformers.

At Vienna, the system proposed by M. Monnier, and successfully carried out by myself, consists of charging from a central station groups of batteries of accumulators, charged continuously in series. From each group four circuits are led off, so as to cut down the E.M.F. from 400 volts to 100 volts, to suit the lamps used. This system has now been in use continuously for six months, and there has been no hitch or trouble whatever in working the plant. It is almost needless here to remark that the troubles connected with the boilers about which so much has been written, have had nothing whatever to do with the electrical plant. No difficulty has been experienced in charging continuously at the high pressure necessary, and although no special precautions were taken with the inside wiring of the opera, and other places supplied, no danger or difficulty has arisen from the use of this high pressure. We may therefore consider it proved that a system of supply which uses a charging current at a potential sufficient to fully charge four batteries arranged in series each at 100 volts, and which supplies at times of average maximum demand for electricity, two-thirds of the current direct from the dynamos without any loss whatever, and one-third only from the accumulators, can be worked successfully and economically, and with a far greater margin of security against temporary stoppages of the light than could possibly be the case with either alternating or direct current transformers without storage.

It remains now to compare the cost of the B.T. system when applied to an anstallation of the dimensions proposed in the article, with the figures given as the cost of the installation by alternating current transformers. Taking the items in the order previously given, I shall consider first the cost of motive and dynamo power. As I have said, the dynamos supply two-thirds of the maximum net output of 600 kilo-watts, and as in this case there will be no loss of current, but only of E.M.F., in the regulating appliances, which may be safely taken at 12 per cent., we require 448 kilo-watts at the terminals of the batteries, or, adding the 10 per cent. loss in the mains, 500 kilo-watts in the generating station. If I add to this the 20 per cent. of extra motive and dynamo power the writer of the previous article proposes to allow as reserve, we must provide for 600 kilo-watts, equal to 1,000 i.-h.-p. Such a plant may conveniently consist of six sets of combined engines and dynamos, each of 100 kilo-watts, or 166 i.-h.-p.

£12 per i.-h.-p., the sum allowed in the former article, appears to me an excessive estimate for engines and boilers only, and, as it tells equally on both sides of the comparison, I propose to reduce it in both cases to £8 12s. per i.-h.-p., for which sum, I believe, more than one contractor of repute could be found ready to supply and fix the boilers, steam and exhaust pipes, feed aapparatus, triple expansion engines, ready to be coupled on to the dynamos. I adopt the figures given as the cost of the dynamos, and from the two I work out the cost of the motive power to £8,700, and the dynamo power £4,800. For the A.T. system I adopt the figures formerly given—viz., 1,450 i.-h.-p., which at £8 12s. comes to £12,500, and for the dynamos and exciters £5,540. For purposes of comparison, a sum ought to be added representing the cost of site and buildings in both cases; and, as stated in the article, the cost of this would be nearly in proportion to the space occupied by the machinery. I propose to add on this account £8,000 to the B.T. system and £11,000 to the A.T. system. Next as to cost of charging mains. As I read the article, these mains in the case of the B.T system will extend only from the generating station to

the accumulator stations in the district. If we take the length of this main at one mile exterior to the district, and 240 yards inside it, or 2,000 yards in all, the total length of circuit being 4,000 yards, the current 1,200 amperes, and a loss allowed of 10 per cent. or 40 volts, its resistance must be 0·04 ohm. A double conductor, having a collective area of about 2·55 square inches, weighing about 45 tons, and costing at £80 a ton, £3,650, will be sufficient. This can be laid, supported on earthenware or porcelain insulators, in a brickwork-in-cement culvert, for £1,500 or, say, £5,150 in all. In the case of the A.T. system, the mains, for purposes of comparison, must be laid under ground, and as in this case the charging mains are practically co extensive with the charging as well as the distributing mains of the B.T. system, it will be convenient to consider the cost of the street work as common to both. The cost of the cheapest and most trustworthy method of laying distributing mains under flag footways, and under ordinary street crossings, varies in London from 14s. a yard of double main, if the section is as small as would be laid for carrying 40 amperes, to 16s. per yard, if conductors having ¼ square inch of section of copper are used.

Before proceeding further, it is necessary to consider what length of house frontage will be probably required for a supply of 10,000 60-watt lamps burning simultaneously. I believe recent experience in London and elsewhere has shown that the ampere at 100 volts, *i.e.*, 100 watts per yard of useful frontage of houses supplied, is a good figure to use. For the 6,000 ampere or 600 kilowatts we supply 6,000 yards of useful frontage, and this on the supposition that every house takes the light. But it is not unreasonable to say that for years to come 50 per cent. in excess of this frontage must be supplied with mains, or 9,000 yards actually facing the houses, to which we must add at least 35 per cent. for crossings and other portions of the road traversed by the mains, which do not face what I call useful frontage. This makes 12,000 yards in all. From the figures I have before given, these 12,000 yards of distributing mains for the B.T. system, at ¼in. section of conductor, would cost £9,600; and those for the A.T., at the smallest useful section, would cost £8,400. To the latter figure must be added an item of £2,400 as the cost of one mile of main outside the area of supply. Before leaving the subject of the distributing mains it will be convenient here to consider the question of the cost of the house connections. When underground conductors are used it is necessary to provide one surface box with connections for every two houses. Now, as the whole of these must be put down in the first instance at the time the mains are laid, we must estimate for their supply for both systems. In London the house fronts vary from 24ft. to 60ft., and taking the rather high average of 30ft., or 10 yards, we would require a surface box for every 20 yards, or 450 boxes for the 9,000 yards of useful frontage. Pricing these at £2 for each surface box fixed, we must add £900 to both estimates.

The battery transformers have to supply 200 kilo-watts per hour during the hours of maximum supply. A great deal hangs on this most important question of the duration of the hours of maximum supply; but in London it is found not to extend beyond three hours per day in winter. If we supply four batteries of accumulators which will have a total capacity of 1,000 kilo-watts, we shall provide for five hours of extreme demand, which is a condition of things extremely unlikely to occur, even in times of fog. We require thus four batteries, each having a capacity of 250 kilo-watts, and capable of being discharged at fair efficiency, at a rate of not less than 650 kilo-watts. Such accumulators can be obtained, either in England or on the Continent, from at least three different makers, and can be fixed and set to work for the sum of £8,640. In one of these cases the makers guarantee that, to meet a breakdown of the charging plant or of the charging mains, a demand at the rate of 250 kilo-watts can be supplied by each battery without injuring it in any way, but of course for a comparatively limited period. This would provide against any panic or annoyance to the users of the light caused by a temporary stoppage of the charging current, even if it occurred at the period of maximum demand. In all such cases as this which I am now estimating, when ample allowance has been made for spare machinery, and when the charging mains can be laid and insulated in two parallel sections, such stoppages are unlikely to extend beyond a few minutes, so that in this point the B.T. system offers enormous advantages over its rivals.

The cost of the alternating transformers appears to have been largely under estimated in the former articles. The writer there stated that a maximum supply of 10,000 lamps would be obtained from such a small number as 150 transformers. Most people will admit that such distribution is extremely unlikely to occur in London, whatever might be the case in New York or some of the Continental towns. When I was above considering the distributing mains I showed that 9,000 yards of mains fronting the houses would be required in order to obtain 10,000 lamps lighted simultaneously, and I suppose that these mains would front 900 houses, of which only 600 would take the light. It follows that, if every consumer has his own transformer fixed, 600 must be provided, and at the lowest estimate this could not be done, including the fixing of them, at a less charge than £20 per house, or £12,000 for the whole. Even if we suppose that one transformer could be provided for every two houses, we cannot estimate the total cost at less than £7,500; and in order to avoid possible criticism on this ground, I propose to enter this lower figure in my comparative statement; but it will be very interesting to hear the opinion of the advocates of the A.T. system on this point, as it very vitally affects its first cost. The statement I have thus arrived at shows that the cost of 10,000 60-watt lamps supplied simultaneously will be approximately the same, viz., £49,000 for both systems, a result which differs very widely from the figures given in the previous article. I leave the figures to speak for themselves, and shall have more to say on the matter after I have heard a few of the criticisms which I may reasonably expect from those who believe in the A.T. system.

COST OF GENERATING AND DISTRIBUTING PLANT FOR 10,000 60-WATT GLOW LAMPS, BURNING SIMULTANEOUSLY.

With Secondary Batteries.

Motive power, six 166 i.-h.-p. setts = 996 i.-h.-p., at £8. 12s.	£8,700	0	0
Dynamos	4,800	0	0
Building to suit above	8,000	0	0
Charging main, 45 tons at £80	3,650	0	0
Laying ditto in culvert	1,500	0	0
Distributing mains, 12,000 yards at 16s. per yard	9,600	0	0
Service boxes, 450 at £2	900	0	0
Batteries, four sets of 50 cells each	8,640	0	0
Regulating gear	1,000	0	0
	£48,790	0	0

With Alternate Current Transformers.

1,450 i.-h.-p., at £8. 12s. per i.-h.-p.	£12,500	0	0
Dynamos and exciters	5,540	0	0
Building to suit above	11,000	0	0
Charging main	2,400	0	0
Distributing main, 12,000 yards at 14s. per yard	8,400	0	0
Service boxes, 450 at £2	900	0	0
Regulating gear	500	0	0
Transformers, assuming one large one for two houses, 300 at £25 (including fixing)	7,500	0	0
	£48,740	0	0

Effect of Light on the Electric Discharge.—It has been conclusively established by the researches of Prof. H. Hertz that the extreme ultra violet rays of the spectrum have a certain influence on the passage of the electrical spark, by which the potential at which discharge takes place is sensibly diminished. These researches have been supplemented by those of E. Wiedemann and H. Ebert, who have found that the effect is not limited to the ultra violet rays, but extends to the more refrangible visible rays of the spectrum. They point out also the curious circumstance that the effect takes place only when negative electricity passes through the spark region. In the case of positive electricity, no difference was noticed when the spark region was illuminated. In the Geissler tube the discharge of negative electricity, which was intermittent when no light fell on the spark, became continuous when the spark region was subjected to the action of the violet or ultra violet rays.

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

FIRE OFFICE RULES.

The electric lighting industry is subject to two kinds of adverse influences, those arising from within and those arising from without, of which the former are the worst. Insurance is universal. Electrical engineers know that the buildings they light have to be insured, and it is in their interest that the work done should be of such a character as to conform to the rules of the insurance office. The latter has to pay the piper, and must, of necessity, call the tune. Compliance therewith is a matter of detail. An electrical contractor, in his communiation to our columns last week, directed attention to the fact that a new set of rules had been issued which would have the result of introducing confusion everywhere. We have to deal with actual facts, and, in face of these, would make certain suggestions. It is a fact—and, if there be any who doubt the statement, they may, by a little investigation, prove the assertion for themselves—that, so far, the only rules followed in practice have been those of the Phœnix Fire Office. These have grown with the growth of the industry, and were the outcome of the united experiences of the engineer of the company and the best electric light contractors. They have been found to work fairly well, and, all important from the insurance point of view, have, when followed, proved effective in preventing fires. This, too, should add to their value from the electrical engineer's point of view. It surely is not in his interest to have a disastrous fire traced to his work. Our readers must bear with us if we say hard things. We have to look at the future as well as the present. The firm getting an order for an installation is no doubt pleased in the extreme. The work is done; the money received, and the profit added to the bank balance. If, however, the installation does not prove a success, and should, unfortunately, be the cause of a fire, that work does harm to the industry out of all proportion to the money value of the work done. Our cry then should be "rather too strict than not strict enough." If the Phœnix rules were calculated to unduly put forward that office there might be some reason for having other sets but surely any office can accept a risk under these rules. The multiplication of rules will add immensely to the difficulties of electric light engineers, and especially so in the question of tendering. It may be said that the consulting electrician will specify under what set of rules the contractor has to tender, and it is implied that the consulting electrician will use those rules which meet with his approval. That is impossible unless all meet with his approval; for in most leases it is distinctly stated the insurance must be in such and such an office. The solicitor settles which office before the tenant comes in, and long before the consulting electrician comes to the front. It may be argued that the electrician will

tical conclusions of the lecturer. In the first place the material of which the rods are composed may, on the whole, be better of galvanised iron than of copper. To protect high chimneys, a sheet of metal on the top, connected to a number of points similar to those of barbed wire fencing, and in contact downwards, by ordinary galvanised telegraph wires, to bands of metal around the chimney, the wires ultimately making in duplicate as good "earth" as can be obtained, constitutes probably the best solution of the problem. The protection of ordinary houses should be by barbed wires along ridges and eaves connected to the water pipes, but not to the gas pipes, nor to projecting iron balconies, and taken to good "earth" by ordinary galvanised telegraph wires. If the whole roof can be of metal so much the better. It is a mistake to think that an ordinary lightning conductor protects a given area; it does nothing of the kind, and the theorising of the French writers in this direction, pricked as it was by Mr. Preece some years ago, must now be taken to be completely exploded. We have been among those who heretofore insisted upon periodical testing, but our views are somewhat modified upon this point; not, however, as to the testing, but more as to the manner of testing. Prof. Lodge suggested a method of testing which no doubt will receive careful attention from practical men; but it will be best to leave discussion upon this part of the subject for a future opportunity. Meanwhile there can be little doubt as to the correctness of the general conclusions advanced. They accord with experimental evidence.

CORRESPONDENCE.

FIRE OFFICE RULES.

To the Editor of the Electrical Engineer.

Sir: However great the difference of opinion existing between electric light contractors and fire office inspectors, the advent of two more sets of rules in addition to those of the Phœnix Fire Insurance Office will not tend to simplify matters.

It is to everyone's interest to reduce electric lighting to its simplest form, an object which will certainly not be forwarded by having various authorities all looking at the subject from their own point of view.

The stage to which matters has come has more especially been brought under my notice by my having been asked to draw up a set of rules for one of the larger fire insurance offices. The effect upon the public mind will hardly be reassuring when they have to choose between conflicting opinions, every one of which is said by its upholder to be the one and only way of carrying out electric light installations.

Whilst one does not wish an approach to the "go-as-you-please" license given to gas engineers, one does not wish to fall into the opposite extreme of having to take unnecessary precautions.

I had hoped that the days of firms who put in second-class materials and scamp their work were coming to an end, but the time for this seems to be likely to be still further prolonged if there are several standards of work.

Unless the Society of Electrical Engineers or the Dynamicables will take the matter up in a broad spirit, it would be as well to have a meeting of those interested, and for them to appoint a committee consisting of representatives of the fire offices, the electrical societies, consulting engineers, and electric lighting firms, &c., to draw up a set of rules. The present Phœnix Fire Office Rules might be taken as a basis, and altered or added to, so as to include any points considered advisable by the committee.

Finally, let this one set of rules be acknowledged, as probably it would be by the fire offices, electrical societies, and the profession generally, as the standard by which work must be carried out.

It might be an advantage to have a committee of appeal for new and disputed points in installation work, and there also might be a definite list of risks made out for different classes of buildings, such as theatres, private houses, mills, &c., together with the class and description of insulation that would be passed for such risks—this probably varying with different systems of lighting and the rate at which the building is insured.—Yours, &c., F. L. Rawson.

To the Editor of the Electrical Engineer.

Sir: "Electrical Contractor," in his letter of the 16th inst., puts the question of fresh insurance rules in a very forcible manner.

I do not think that there is the least doubt that if only electrical contractors, as a body, had been consulted, they would have given an unanimous verdict against the issuing of fresh rules, or interfering with those that have so long held the field. These new rules are solely attributable to the unsuccessful attempt, on the part of the Society of Telegraph-Engineers, to obtain for themselves the credit of having originated the only recognised insurance rules in existence. If there is a *clique* who seem to have tardily discovered the fact that they have had no hand in the issuing of these rules, and have some objections to them, why do they not come forward and state those objections?

If they did this I feel confident that the Phœnix Company would be only too glad to entertain any reasonable suggestions they might make in order to render their rules as perfect as possible. This issuing of fresh rules will create the utmost trouble and confusion, especially amongst good and first-rate firms, who will be cut out altogether by those who will take advantage of a multiplicity of rules to put up cheap and bad work, besides unnecessarily alarming the public, who will immediately take it for granted that if electricians cannot mutually agree how to put up installations there must be very considerable danger run in adopting the electric light.

In future, how are specifications to be drawn up for installations? Which set of rules will be taken as a basis of the way in which the work is to be executed? Supposing a building is fitted with the electric light, and insured in several offices, each having its own set of rules, how will it be possible for the contractor to get his work passed by the various insurance inspectors if each is going upon his own lines? Hitherto, where a case has arisen as above, it has nearly always been sufficient to inform the other insurance offices that the installation had been put up in accordance with the Phœnix Fire Office Rules, and passed by Mr. Heaphy. Now all this will be changed, and contractors will have a sorry time of it. Consulting electricians will also be powerless to better the situation, as they cannot hope to get rival promoters of rules to agree to any but their own.

This question is of such momentous importance to all electrical firms that unless a combined movement be made, and that at once, to counteract this action, a blow will be struck at our industry from which we shall suffer long and severely.

As it seems to be a question that only concerns electrical contractors, and not telegraph-engineers, professors, or other learned scientists, the former should at once take steps to bring forward their united opinions, and, in so doing, I hope there will be many who will share the views of Another Electrical Contractor.

March 20th, 1888.

ALTERNATE CURRENT TRANSFORMERS.

To the Editor of the Electrical Engineer.

Sir: I notice in your late issues a series of reports of the discussion on the above subject at the Society of Telegraph-

very difficult mechanical problem to convey the same amount of energy by a wire rope as in the cable system. The weight of the cable has to be moved, and it must be supported by sheaves placed along the line at short intervals, while a large tunnel must be built to contain it. The sheaves all consume power, and have to be constantly oiled and watched, and by their constant recurrence prevent any thorough cleansing of the conduit. Elaborate and complicated construction is necessary for curves and switches, while the connecting and disconnecting of a heavily-loaded car to and from a swiftly moving cable is a difficult and wearing process. The best cable engineers estimate that more than 75 per cent. of the engine power is consumed in moving the dead weight of the cable, and this rarely lasts over a year, or a year and a half. When electricity is used, on the other hand, the conduit contains only the stationary and permanent copper rods, and no mechanism is employed to wear and give trouble. Connection with the car is maintained by a light sliding contact bearing gently against the conductors, and the conduit excavation need be only large enough to permit of drainage between catch bits. So far, then, as the transmission of power is concerned, the simplicity and convenience of the electrical method is unrivalled.

Its efficiency is equally satisfactory. The dynamo-electric machine, by which the power of the steam-engine is converted into electricity, has reached a degree of perfection unappreciated by those not engaged in the business. Less than five years ago the best dynamos gave an efficiency of 75 per cent.; there was an excessive heating of the wire coils and of the journals, so that a machine could rarely be depended upon for a run of twelve to eighteen hours at a stretch. There were frequent burnings out of the armature and of the commutator, and other recurring faults, which caused uncertainty and expense. At present the best manufacturers sell their machines, both dynamos and motors, with a guaranteed efficiency of 90 per cent., so that for every 100 h.-p. of the steam-engine 90 will appear on the line in electricity, and 81 will appear in the motor in the form of mechanical energy. The latest series of tests made with railway motors demonstrated an efficiency of 80 per cent. from the steam-engine to the car axle. From this must be deducted, in actual practice, 5 per cent. for the line wire, and 10 per cent. for contingencies of all kinds, leaving 65 per cent. actually to be relied on. Therefore, from 100 h.-p. at the engine, 65 will be delivered on the car axle.

The capacity of machines has increased in like ratio. A machine that would formerly operate 35 or 40 arc lamps has been worked up to operate 65. At the same time the reliability of machines has been improved. Their electrical and mechanical construction has been brought to such a degree of perfection that little more can be desired. And while the electrical machines have been worked up to this point, special engines for driving them have been developed, and special appliances devised for protecting both dynamos and engines from all possible accidents and interruptions. This growth has been unostentatious, but rapid and sure; and at present the transmission of energy by electricity is thoroughly and completely practicable, thousands of horse-power being every day obtained from electric motors. The application of the motor to railway use has been steadily developed during the last four years. Various difficulties have been met and overcome. The conduit system, involving greater difficulties and expense than the overhead system, has gone somewhat slower, but both are now in shape for practical everyday use. The peculiar adaptability of the electric motor to railway use is not fully appreciated except by those intimately acquainted with it. It will be described in this article as plainly as possible in the space that is available.

The work of propelling a tramcar is characterised by wide variations in the amount of power required, and by wide variations in the character of it. The power is measured by the product of the tractive pull into the velocity, and there is found to be a variation in the total product required, and also a variation in each of the factors entering into it. A motor for street-car work must be capable of wide variation in tractive force to correspond with the variations in grade on the line. The quite ordinary grade of 5 per cent., for instance, may require about eight times the traction that is necessary on a level. For this reason motors that have but little range of pressure must fail; for while on a level the pressure will be ample for the load and will accelerate the speed so as to do a large amount of work, it will not give sufficient traction for a grade or curve. In an electric motor, on the other hand, the pull increases as the square of the current, and is limited only by the magnetic saturation of the iron cores. This limit is so remote that it is best appreciated by the fact that in practice a motor capable of moving 15 tons up a grade of 8 per cent. weighs, with gearing, but 1,600lb. By admitting three times the current to the motor that is necessary on a level, the traction can be increased nine times.

It is another peculiar feature that the necessary increase of current automatically takes place by reason of the tendency of the electric motor to slow up under an increased load. This slowing tendency and the acceleration due to the resulting increase of current, meet each other at a point always dependent on the load at any given time. This follows from the following considerations: A dynamo and motor are the same machine working in converse ways, the dynamo converting mechanical into electrical energy, and the motor converting back electrical into mechanical energy. When acting as a dynamo the machine has also a motor action, due to its own current, which opposes the driving engine, and in overcoming which the power of the engine is consumed. When acting as a motor, on the other hand, it has also a dynamo action, tending to set up an electromotive force against the direct or actuating electromotive force. The efficiency of the transmission depends on the ratio between the direct and counter electromotive forces, and, as the resistance of the motor is constant, the current through it will depend on the excess of the one over the other. Any slowing of the speed, therefore, causes a large current to pass through the motor, and this produces a much greater traction, since the traction increases as the square of the current. There are other elements which come in to modify this result somewhat, but which we need not enter into. As a fact in practice, the traction automatically increases in a much greater ratio than the speed decreases, corresponding very closely with the variations in traction and speed that the service on most short railways demands. For the large majority of cases, therefore, the electric motor is nearly self-regulating, an artificial resistance being used for stopping, and occasionally for going very slowly and restraining too high a speed.

The great capacity and compactness of the electric motor are evident qualifications for railway work.

THE INSTITUTION OF CIVIL ENGINEERS.

At the ordinary meeting on Tuesday, the 13th of March, the President, Mr. Bruce, being in the chair, the paper read was on "Economy Trials of a Non-Condensing Steam Engine—Simple, Compound, and Triple," by Mr. P. W. Willans, M.I.C.E.

The author described a series of economy trials, non-condensing, made with one of his "central-valve" triple-expansion engines, with one crank, having three cylinders in line. By removing one or both of the upper pistons the engine could be easily changed into a compound or into a simple engine at pleasure. Distinct groups of trials were thus carried out under conditions very favourable to a satisfactory comparison of results. No jackets were used, and no addition had, therefore, to be made to the figures given for feed-water consumption on that account. Most of the trials were conducted by the author, but check-trials were made by Mr. MacFarlane Gray, Professor Kennedy, Mr. Druitt Halpin, Professor Unwin, and Mr. Wilson Hartnell. The work theoretically due from a given quantity of steam at given pressure, exhausting into the atmosphere, was first considered. By a formula deduced from the θ ϕ diagram of Mr. MacFarlane Gray, which agreed in results with the less simple formulas of Rankine and Clausius, the lbs. weight of steam of various pressures required theoretically per indicated h.-p. hour were ascertained (see table). A description was then given of the main series of trials, all at 400 revolutions per minute, of the appliances

Intended mean admission-pressure ... lb.	40	90		110		130	150		160		170
Simple, compound, or triple.	S.	S.	C.	S.	C.	C.	C.	T.	C.	T.	T.
Actual mean admission-pressure ... lb.	40·88	92·65	87·54	106·3	109·3	130·6	149·9	151·9	158·5	158 1	172·5
Percentage ratio of actual mean pressure, referred to l.-p. piston, to theoretical mean pressure ...	98·2	100	91·3	100·7	94·8	94·2	94·6	84·54	95·9	85·3	85·2
Indicated horse-power ...	16·51	31·61	29·14	33·5	33·0	36·31	38·59	35·69	39·55	35·56	38·45
Feed-water actually used per indicated h.-p. hour—											
Simple ... lb.	42·76	26·89	—	26·0	—	—	—	—	—	—	—
Compound ... lb.	—	—	24·16	—	21·37	20·35	19·45	—	19·19	—	—
Triple ... lb.	—	—	—	—	—	—	—	19·68	—	19·19	18·45
Steam required theoretically per indicated h.-p. hour... lb.	34·67	19·24	19·86	17·9	17·65	16·25	15·23	15·16	14 87	14·9	14·36
Percentage efficiency...	81·1	71·5	82·2	68·8	82·5	80 0	78·3	77·0	77·4	77·6	77·8
Percentage of feed-water missing at cut-off in h.h.-p. cylinder.	—	—	—	—	—	—	—	5·33	—	6·84	5·01
Ditto h.-p. cylinder ...	—	—	5·0	—	9·5	11·7	15·1	14·84	17·0	12·06	15·33
Ditto l.-p. cylinder ...	11·7	24·8	15·2	29·56	16·25	19·1	20·6	22·12	21·3	22·11	24·21
Percentage of feed-water missing at end of stroke in l.-p. cylinder ...	10·4	18·83	14·25	21·53	16·59	17·55	20·69	18·01	19·55	18·81	19·25

used, and of the means taken to ensure accuracy. A few of the results were embodied in the table. The missing quantity of feed-water at cut-off, which, in the simple trials, rose from 11·7 per cent. of 40lb. absolute pressure to nearly 30 per cent. at 110lb., and at 90lb. was 24·8 per cent., was at 90lb. only 5 per cent. in the compound trials. In the latter, at 160lb., it increased to 17 per cent.; but on repeating the trial with triple-expansion it fell to 5·46 per cent., or to 4·43 per cent. in another trial not included in the table.

On the other hand, from the greater loss in passages, &c., the compound engine must always give a smaller diagram, considered with reference to the steam present at cut-off, than a simple engine, and a triple a smaller diagram than a compound engine. Nevertheless, even at 80lb. absolute pressure the compound engine had considerable advantage, not only from lessened initial condensation, but from smaller loss from clearances, and from reducing both the amount of leakage and the loss resulting from it. These gains became more apparent with increasing wear. The greater service in a compound engine had not the injurious effect sometimes attributed to it, and the author showed how much less the theoretical diagram was reduced, by the two small areas taken out of it, in a compound engine than by the single large area abstracted in a simple engine. The trials completely confirmed the view that the compound engine owed its superiority to reduced range of temperature. At the unavoidably restricted pressures of the triple trials, the lossess due to the new set of passages, &c., almost neutralized the saving in initial condensation; but with increased pressure, say to 200lb. absolute, there would evidently be considerable economy. The figures of these trials showed that the loss of pressure due to passages was far greater with high than with low-pressure steam, and that pipes and passages should be proportioned with reference to the weight of steam passing and not for a particular velocity merely. The author described a series of calorimetric tests upon a large scale (usually with over two tons of water), the results of which were stated to be very consistent. After comparing the rates of initial condensation in cases where the density of steam, the area of exposed surface, and the range of temperature, were all variables, with other cases (1) where the density was constant, and (2) where the surface was constant, the author concluded that, at 400 revolutions per minute, the amount of initial condensation depended chiefly on the range of temperature in the cylinder, and not upon the density of the steam, or upon the extent of surface; and that its cause was probably the alternate heating and cooling of a small body of water retained in the cylinder. The effect of water, intentionally introduced into the air-cushion cylinder, corroborated the author's views, and he showed how small a quantity of water retained in the cylinder would account for the effects observed. At lower speeds surface might have more influence. The favourable economical effect of high rotative speed, *per se*, was very apparent. In a trial with a compound engine, with 130lb. absolute pressure, the missing quantity, at cut-off rose from 11·7 per cent. at 405 revolutions to 29·66 per cent. at 130 revolutions, the consumption of feed-water increasing from 20·35lb. to 23·67lb. This saving of 14 per cent. was due solely to increase of speed. Similar trials had been made with a simple engine. In one simple trial at slow speed the missing quantity rose to 44·5 per cent. of the whole feed-water. The author compared a series of compound trials, at different powers, with 130lb. absolute pressure, and various ratios of expansion, with a series giving approximately the same powers at a constant ratio of expansion, but with varying pressures, being practically a trial of automatic expansion against throttling. Starting with 40 indicated h.-p., 130lb. absolute pressure, four expansions, and a consumption of 20·75lb. of water, the plan of varying the expansion, as compared with throttling, showed a gain of about 7 per cent. at 30 indicated h.-p., but of a very small percentage when below half-power. If the engine had an ordinary slide-valve, the greater friction, added to irregular motion, would probably neutralize the saving, while if the engine were one in which initial condensation assumed more usual proportions, the gain would be probably on the side of variable pressure. Even as it was, the diagrams showed that the missing quantity became enormously large as the expansion increased. Judging only by the feed-water accounted for by the indicator, the automatic engine appeared greatly the more economical; but actual measurement of the feed-water disproved this. The position of the automatic engine was, however, relatively more favourable when simple than when compound. In conclusion, the author referred to a trial with a condensing engine, at 170lb. absolute pressure, in which the feed-water used was 15·1lb., a result evidently capable of further improvement, and to an efficiency trial of a combined central-valve engine and Siemens' dynamo, made for the Admiralty, at various powers. At the highest power the ratio of external electrical h.-p. to indicated h.-p. in the engine was 82·3 per cent. Taking the thermo-dynamic efficiency of the engine at 80 per cent., that of the combined apparatus would be nearly 66 per cent.

Electric Motors.—Mr. F. L. Pope, in an article which appears in *Scribner's Magazine*, draws attention to the ignorance which prevails in the popular mind in reference to the true position of the electric motor. Thus he shows that the idea of employing this motor to propel vessels across the Atlantic, for instance, is altogether a fallacy. He points out that electricity in its application to machinery is not in itself a source of power, but is merely a convenient and easily manageable derived form of energy. At the best, he says, the electric motor is only a secondary motor, which must derive its power from some primary motor, such as a steam engine or turbine. This latter statement would not apply, however, if the electric motor were worked in connection with a thermo-electric generator. But, unfortunately, we can at the present moment see no prospect of the thermo-electric battery becoming an economical means of converting heat into electrical energy. Until some such means be perfected, the field practically occupied by the electric motor must be that of supplying a convenient means for distributing the power economically evolved on a large scale by prime motors worked by steam, water or, perhaps, wind.

INDEPENDENT ENGINES IN INDEPENDENT STATIONS.*

BY WILLIAM LEE CHURCH.

(Concluded from page 249.)

The typical daily chart of amperes delivered from an incandescent station of, say, 4,500 lights, is shown in Fig. 2, of course with variations in different stations, but always of the same general character. The chart is assumed to cover a winter night's run, commencing at 4 p.m., and shutting down at 8 a.m. The heavy, irregular line A B represents the fluctuation of the actual load, such as would be determined by indicating a series of independent engines; and the area enclosed between it in the base line M N may be denominated by the net power required. The fine, irregular line C D encloses the gross load when driven by a single large engine, being equivalent to the net load plus the friction of the shafting and pulleys required in transmission. The irregular band lying between A B and C D, therefore, represents the dead load, which would be a dead loss, due to the friction of the shafting. But, as shown above, this is the full measure of the loss. We have already seen in, Fig. 1, that an excessive underload requires a relative amount of steam which would be adequate to produce a much greater power if applied in an engine worked at its point of maximum efficiency. Combining the two diagrams, therefore, we would find a third dotted line, E F, which would clearly represent the actual steam consumption required to secure the network A B. The irregular band, therefore, between A B and E F, represents the total loss expressed in coal; in other words, the entire area E F M N represents the lamps which should be got for the steam expended, whereas

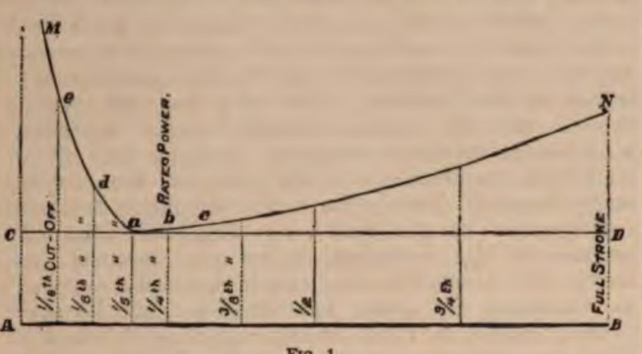


Fig. 1.

Fig. 1 illustrates the paragraph on Corliss engine—*a b* indicates cut-off, C D rate of consumption if economy unaffected by the load. If diagram represents actual performance it shows engine is at its best only from *a* to *c*.

A B M N represents the lamps actually got for the steam expended. The loss involved is practically 50 per cent. of the total fuel in the whole night's run, which corresponds to observed results in stations whose fluctuations of load are about as indicated. Of course there are stations in which the net load averages more uniform than that shown, and a better proportionate result would therefore be expected from the single large engine with countershafting. We believe it is safe to say, however, that there is no incandescent station which will get a load so constant as to secure the economy from a single engine equal to that which can be realised from subdivided power.

We now contrast the performance of independent engines in the same station. The lower narrow band between the lines M N and *a a* represents the smallest dynamo, equal to a load of 650 lights. The remaining three bands between *a a*, *b b*, and *c c* represent the other dynamos, or successive loads of 1,300 lights each. At starting time, therefore, a 60 h.-p. engine with its 650-light dynamo is started, and run continuously until shutting down in the morning. It will be noted that, while running, the load on this engine is practically constant and at the point of maximum efficiency. In ten minutes after starting, the load rapidly increasing, it becomes necessary to start the second 125 h.-p. engine with its 1,300-light dynamo, which engine again runs on its full and most efficient load, as indicated between the lines *a a*, *b b*. This engine is stopped at 12:45, and is therefore running to a disadvantage only for the last hour. At 4:40 the increase of light calls for the third engine with its dynamo, which in turn runs until 10:45, and is then stopped. The fourth engine and dynamo will start at 5 p.m., and run until 9:30. The point to be clearly understood as vital to the whole economic question is that each engine while running is loaded to its best efficiency, runs only so long as its load is called for, then stops altogether, and with it all consumption of steam, leakage, radiation, wear and tear, and loss of every nature. Ample time is given to inspect the engine and dynamo if necessary, and the system as a whole develops the last possibilities of commercial efficiency.

The above diagram practically represents the performance of two stations which we once had the privilege of comparing. Both were practically the same size, and both were constructed on the same electrical basis. We were by courtesy put in possession of the monthly reports from both of these stations, which showed a ratio between the pounds of coal per ampere per hour of 70 to 126 in favour of the station driven by independent engines. A station whose motive power is one or two large engines, therefore, finds itself in a position of earning money between starting time and 10 o'clock, and spending it again between 10 o'clock and morning.

We have thus endeavoured to make it clear in the above illustrations that the rated economy of the two types of engines is but a small part of the consideration, and cuts practically no figure whatever in actual practice under the conditions imposed by the nature of incandescent service.

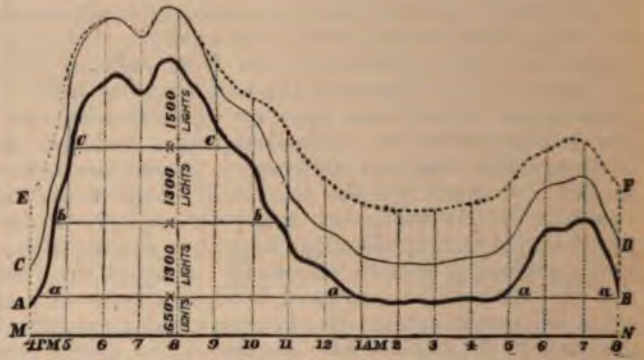


Fig. 2.

If any one is now thinking to inquire, why not use a number of small Corliss engines in place of high-speed engines, if it is admitted that the Corliss type is more economical of the two? we would answer briefly, first, small Corliss engines are not as economical as small single-valve engines, the percentage of leakage due to the four valves and slower speed being much greater; second, small engines of the Corliss type run necessarily at so slow a speed as to preclude the possibility of direct belting, and to involve full lines of counter-shafting with their attendant cost and waste of power; third, the first cost of small slow-speed engines is very greatly in excess of that of high-speed engines of the same power. We think no one has ever seriously considered, however, the adoption of small independent slow-speed engines.

Next in importance to reliability and economy is uniformity, delicacy, and continuity of regulation.

There is much misapprehension regarding the matter of regulation in engines used for electric lighting. Let us, therefore, ask, What is good regulation? Good regulation implies, as a matter of course, reasonably small variation of speed, reckoned in R.P.M., between the engine fully loaded and the engine running light. Claims are made that such and such engines regulate to 2 per cent., 1 per cent., and even to one-half of one per cent., under variations of load. Now, it should be clearly understood, once for all, that any decent automatic engine controlled by the shaft governor can be so adjusted as to not merely to 2 per cent., or 1 per cent., but to actually pass the point of exact regulation, and run faster under load than when light. So far

* *Paper read before the* National Electric Light Association.

as regulation in terms of R.P.H. is concerned 1 per cent. or 2 per cent. regulation is sufficiently close for all ordinary purposes.

Second. The most important consideration in the regulation of engines in incandescent stations is not their variation from minute to minute, but from stroke to stroke. An engine may make 300 turns per minute, counted for each successive minute of the hour, and yet may at any given instant be running sensibly above or below this speed, in the effort to meet a momentary fluctuation of load. We say every engine may do this, and we have observed that most engines do this frequently; the difficulty being, not a matter of the construction of the governor, but purely a question of lubrication. A perfect governor is one which will maintain the speed, not at an average of 300 R.P.M., but at the rate of 300 R.P.M. for each and every stroke. Any properly constructed governor will retain the average of regulation to which it is set, but it can only secure instantaneous regulation when friction is practically eliminated. It has been our experience that nothing but a complete bathing of the governor in oil will practically accomplish this purpose, and maintain its perfection throughout a long run.

Incandescent lamps require a regulation more delicate, perhaps, than any other industry. Any departure in regulation from stroke to stroke gives a variation of electromotive force, which is speedily destructive to the life of the lamp—the item which, next to fuel economy, is the heaviest taxation. The injury is done during the period of acceleration immediately following the change of load, which period is the time between the change of load and the movement of the governor; and this in turn is proportional to the friction. It is obvious that, if friction were annihilated, the acceleration would be also *nil*, and the speed, and consequently the electromotive force, would never vary.

Third. Under the extremely long runs now imposed by electric lighting service continuity of good regulation is essential; that is to say, a governor which will regulate when well oiled will fail to regulate when its pins and bearings, being inaccessible under motion, have become dry during a long run.

As to the nicety of regulation obtainable from a slow-speed engine, there is no comparison possible. We have already shown that it is not permissible for an electric light engine to vary its speed, even from stroke to stroke. A slow-speed engine not only may do this, but actually does vary its speed within the limits of a single stroke. All observers know that it is frequently quite possible to count the revolutions of a slow-speed engine, particularly when heavily loaded, by the pulsations in the lamps at a distance from the station. A slow-speed engine, unless excessive in its fly-wheel capacity, will imperceptibly slacken in passing its centres; and this variation, not visible on the engine, becomes a sensible and dangerous variation when multiplied to the speed of the dynamo. The fluctuation of the needle of two voltameters, respectively registering from a high-speed and slow-speed engine will give abundant evidence on this point.

Flexibility.—The characteristic of flexibility in electric light stations is one which is frequently overlooked until experience demonstrates its desirability. To secure the best possibilities in this direction it is necessary to use dynamos of two or three different sizes—say of 650, 1,300, and 2,500 lights capacity—each being driven direct from an independent. The plant being thus divided into independent units of different sizes in any variation of demand, either in the total load or in the load required for different circuits, can be conveniently met. Owing to local causes, the load of a station is not necessarily the same from day to day. It is obvious that a plant in which all the dynamos are hung upon one, or at most two, engines, is essentially rigid in its control of circumstances, whereas a station planned as above indicated, is to the last degree flexible in meeting any variation of load, to whatever degree it may occur. All this has a direct bearing, both on economy of fuel and incidentals of operation.

We would wish to imply that the smallest unit in every station should necessarily be the smallest dynamo—say 650 lights. It is probable that the smallest unit is determined by the minimum load existing at any considerable time during the day. This minimum load in the majority of medium-sized stations will represent about one-eighth to one-sixth the generating capacity of the station; that is to say, a station of 4,000 lights capacity should have one dynamo at least as small as 650 lights. Beyond this, it is perhaps advisable that the units be uniform for the sake of interchangeability of parts. The whole question of units of generation must be considered, not in the light of any one rule, but under all the circumstances of each particular case.

Maintenance of Plant.—The maintenance account of a plant often defeats dividends in the use of counter-shafting, bearings, pulleys, clutch pulleys, belts, &c. No practical operator need be told of the repair account and general annoyance from the use of clutch pulleys. There are incidental exceptions, but we refer to the general rule. Each bearing of the counter-shafting will consume oil to the value of at least five dollars per annum, and any considerable amount of shafting involves the pay of an extra oiler to properly care for it. Regarding the two types of engines under discussion, it is undoubtedly true that the maintenance of the high-speed engine will be fully as low as of an equal horse-power in slow speeds, as to its actual expense, without taking into account the time lost in repairs. Nearly all high-speed engines are made to gauge with more or less reference to interchangeability of parts. Repairs, in consequence, are furnished at a minimum of cost; and, the parts being light and readily handled, the engine can be stripped and overhauled and connected up without the employment of an extra force of men or the necessity of heavy handling. In referring to high-speed engines, we of course only speak of those which are carefully and understandingly designed for the work put upon them—that is, we wish to draw a sharp distinction between high-speed engines and engines speeded high.

Space Occupied.—This is one of the minor considerations which in certain locations becomes of considerable importance. Not infrequently electric light stations are located near the business portion of a city, where real estate is valuable, and taxes correspondingly high, and space counts heavily in the capitalized investment.

Again, a large building obviously increases the investment, particularly when we know that a building to carry heavy lines of shafting at high speeds must be of unusually massive construction. It needs no illustration to show that independent engines, by doing away with the space occupied by counter-shafting and belts under the least distance between centres which can be justified, require materially less space per horse-power than any form of non-subdivided power. This is particularly the case where the dynamos are placed on the second floor, over the engine room.

Moreover, the cramped space in which the single engine must develop and distribute its power is against its satisfactory performance. The fact is generally overlooked in drawing comparisons that a single large engine in an ordinary manufacturing establishment, such as a cotton mill, has in the nature of the case a wide space in which to transmit its power from the slow motions of the engine up to the high speed of the spindles. This means that ample space is given to bring the speed, by gradual accelerations, through easy moving shafting of substantial nature, up to a moderately high intermediate speed, and then distribute it to the spindles in small quantities, by means of simple and light fast-running devices. In the dynamo room, on the contrary, the space is cramped to the last degree, and the slow-running engine must, in short range, multiply its power to high velocities, and transmit its speed in large units to the dynamos. The whole system of transmission becomes rigid and ineffective, and the loss consequent upon friction and risk to *employés*, and the magnitude of disaster when any occurs, are such as in themselves to overbalance all the economy which the most enthusiastic advocates of slow-speed engines attribute to them.

Extension of Plant.—An electric light station, unlike most other industries, is usually, of very rapid and persistent growth, to an extent which is not generally forseen in the original calculation. The use of independent engines lends itself readily to indefinite extension. The power and dynamos both being divided into like units, each indepen-

dent of all the others, extension becomes merely a question of more units, without any special preparation in the plan.

First Cost of Plant.—This consideration, although really of the least importance among those enumerated, is distinctly on the side of subdivided power. The price of the high-speed engine per horse-power is now fully as low, and generally lower, than that of slow-speed engines. Cost of foundation is materially less, as is also cost of erection and handling for repairs. Then there comes into the question the clear saving of all the money invested in countershafting, pulley blocks, heavy belting, clutch pulleys, pulleys, and similar devices. In the station to which we referred above, the extra transmitting devices necessitated the investment of a sum not less than $6,500. The price thus expended would be sufficient to purchase practically 500 h.-p. of independent engines, adequate to generate 6,000 lamps; showing practically net earning capacity of at least $18,000 per annum. When we contrast this with the net losses due to the system of concentrated power, as above discussed, it leaves no room for argument as to the advantages of independent engines in electric light work.

ROYAL METEOROLOGICAL SOCIETY.

In connection with the exhibition, referred to in our Notes, two addresses were given on the evening of the opening day. The first was by the President of the Society (Dr. W. Marcet, F.R.S.), the subject being "Atmospheric Electricity." It was pointed out that the air is always more or less charged with free electricity of a positive or negative kind, and there is reason to believe that every single drop of fluid vesicle that goes to form a cloud is also coated with this subtle agent. Thus, when storm clouds charged with contrary electricity approach each other elongated sparks shoot from one to the other; and when, at last, by their mutual attractions and repulsions, or by the action of the wind, they are brought nearer to one another, lightning flashes in rapid succession illumine the sky and the roar of thunder is heard far and wide. In the same way, when a black storm-cloud charged with positive electricity comes near the earth, the negative electricity which the globe contains is brought to its surface in a state of great tension, and then the two electricities fly towards each other and a flash of lightning is seen. The clap of thunder that follows is the noise of the violent reverberation of air rushing in to fill the vacuum produced by the intense heat of the electric spark. That lightning is nothing more than Nature's electric light, Dr. Marcet showed by producing on the screen magnified images of the sparks thrown off by an electrical machine. In this way the diffused or sheet lightning, with its comparatively straight beam, and the zigzag path of the forked lightning, were graphically exhibited. Dr. Marcet explained briefly the manner in which atmospheric electricity is believed to be concerned in the production of hail, waterspouts, and the aurora borealis.

The second address was by Mr. G. J. Symons, F.R.S., the title of whose paper was "The Non-existence of Thunderbolts, Elucidated by Accounts of Searches After Them." Mr. Symons has endeavoured to track the so-called thunderbolts wherever he could hear of them; but they have vanished before the man of science like ghosts before the daylight. His inquiries showed that there was no more transmission of a thunderbolt, or of any other solid body, when an electric spark rushed through the air, than there is the transmission of a material substance when a message is telegraphed across, or rather under, the Atlantic Ocean. Sometimes a lightning-flash appears to strike the ground, and a spherical nodule of iron pyrites is found near the spot. It was there before. Still, the ignorant imagine it came from the clouds, and with the lightning. Belemnites, which are really fossil animals, are found similarly, and in "Webster's Dictionary" are described as "thunderstones," and as such are often preserved. Occasionally a heavy discharge of lightning falls on a bed of sand, penetrates it for several feet, and melts the silex in its path, fusing it into a kind of glass, which is known as fulgurite—some fine specimens of which are to be found in the British Museum. This, and this only, could have any pretence to be considered a thunderbolt, but then it does not descend from the clouds, and is caused solely by the intense heat of the lighting. Mr. Symons did not deny that solid bodies do at times come down from the sky and strike the earth; but these are meteorites and aerolites—substances ejected from volcanoes or falling upon the earth from planetary space. They are always falling, but when accidentally they descend during a thunderstorm they are instantly designated thunderbolts, though the two phenomena have absolutely no connection. For the credit of Englishmen the lecturer hoped that henceforth the word thunderbolt would be erased from our dictionaries.

THE DISTRIBUTION OF ELECTRICITY BY ALTERNATE CURRENTS.*

BY T. CARPENTER SMITH.

The distribution of electricity by means of alternating currents, though comparatively new in this country, has already reached such an enormous importance, that it is with great hesitation that I venture to speak upon it, even though limiting myself to the strictly practical side of the work, dealing only with the apparatus as we receive it from the hands of the manufacturer, and leaving out entirely the question of the efficiency of dynamos and converters. It is only the knowledge that the mistakes of those who enter upon any new line of business are the rounds of the ladder by which we all attain success that emboldens me to lay before you some of the conclusions at which I have arrived, after several years' experience, of varied types of electric lighting, both by the arc, by the direct current incandescent, and the alternate current incandescent.

The subject naturally divides itself into several heads, but I would first say that it appears impossible to lay down any general plan of distribution, which shall be practicable in all cases. In almost every town a different plan will be required, and this will depend in most cases purely on local circumstances. Systems and methods that would be admirable for thickly settled and densely populated districts will not be successful in thinly populated and widely scattered ones. I wish it to be understood that whenever I speak in this paper of success and successful systems, I mean successful entirely in a commercial way, and the conditions of this commercial success will vary in every town and district. I will, therefore, content myself with describing the method which I have found to be most successful in the various districts with which I have had actual experience, and leave it for those who may be called on to design and lay out the lighting of any particular district to judge for themselves which line of action to pursue.

Naturally, the first part of my subject is the dynamo, and the station detail. I have tried the small and large dynamo, and have concluded that it is a very great point to properly proportion the unit size of dynamo to the probable size of the station; that is, not to have dynamos of different sizes, but to first determine what the unit shall be, making it as large as possible, and then make your whole apparatus additions to that unit size. This simplifies matters very much, enabling machines to be interchangeable, both as regards their parts and their work, and this I am sure will be admitted by all who have ever had the annoyance of a breakdown on engine or machinery, when perhaps they had standing idle plenty of apparatus, which, from various circumstances, could neither be used itself nor be robbed to repair the breakdown.

I would drive each dynamo by a separate engine, and this for several reasons: By proportioning the engine to the dynamo, it will be possible to have the engine running slightly overloaded when the dynamo is doing its utmost during the hours of heavy lighting; and as this extreme load falls off to the lighter hours of running, the engine will be working at its point of best economy, instead of running underloaded, and thereby wasting steam. Thus, we use in our station on Virgin Alley, dynamos of 2,500 lights capacity each, driven by 200 horse-power engines. During 16 hours of the day these dynamos run, driving 2,000 lights, and the engines are cutting off at quarter stroke, and developing 200 horse-power. During the other eight hours we have driven these dynamos as high as 2,800 lights, during which time the engine was of course overloaded, and not working to so good an economy, but eight hours of overload is not nearly so wasteful as sixteen hours of underload; again, we have had it very forcibly demonstrated more than once that if the engine be only large enough to drive the dynamo with ease, a heavy short circuit on the mains outside will simply pull the engine up or slow it down without destroying the dynamo, and only those who have seen a nine foot fly-wheel running at 250 revolutions per minute on a 200 horse-power engine, slowed

* Paper read before the National Electric Light Association, February 23.

wn in almost an instant of time, can realise the terrific which everything is subjected in such cases, and I ention right here that the element of time is a very tor in such circumstances, as, in an accident of this schief is often done before the safety catches can melt e direct belting of the engine to the dynamo is always ferred ; shafting is, except under exceptional circum-simply a nuisance for incandescent electric light stations, economy of one large engine over many small ones has ormously overrated. For arc light work, where the e all lit and extinguished at certain hours, the large good ; but for incandescent work, where the load is y out of the control of the station, it is impossible to run a large engine at anything like its most economical ereas, with separate engines, the machines can be started ped the moment that they are needed or are done with, e oil from shafting will always cause more or less grease

ntral station use, except for very small plants, I should use separately excited dynamos, and should do the from two or more dynamos, each capable of exciting the ystem. In this way, with the station running at its the only regulation required is that obtained by working e rheostat in the field of the exciter, and, as we have our station at Pittsburgh, this will mean the regulation) lights by one six-inch hand wheel. Of course, each should have its separate field rheostat, to make up for t difference in speed of engines. The two exciters e so arranged that they can be run together or separately, ither can do the whole work, which of course is easily shed by feeding them into a separate pair of exciter he switchboard, and charging the fields of the alter-dynamos from these. The general question as to it is better to use separate circuits for separate machines, iple them into a general set of 'bus wires and distribute em, is too large to be lightly decided, as also is the as to whether it is best to run separate circuits for districts, or to run into a general system of high pres-ns outside of the station, feeding into these mains at points, and again distributing from them ; and I am pared to express any preference, but think that local ances will generally decide this question. There seems tle doubt that in underground systems the network of ssure mains would be the best, but for overhead work adopted the system of separate circuits from separate , using a switchboard which enables us practically to circuit or any number of circuits from any dynamo, ing these dynamos separately and not in multiple arc. of the utmost precautions, the unregenerate tele-d telegraph men are always hauling wires across our ssure mains and feeders, and while their wires, and not erally suffer, after hearing the frightful roar that comes e dynamo which is running the particular circuit so we always feel relieved to know that only one dynamo ger of being thrown out by the slipping off of the belt— enty-inch belt is not a pleasant thing to have flying loose. In case of any trouble, such as fire, circuit lown, or anything of that sort, we can pull the switch articular circuit until we can cut out the part affected. em that I have laid out for use here, will, of course, ng time to introduce, in view of the fact that we are from one system to the other, and have to be governed y the location of our lighting, our existing lines, and bility of putting up additional pole lines ; but it takes, ision, the form of a series of heavy mains down the eets, with cross lines on the cross streets, with switches oles, enabling any of the cross streets to be run from s on either of the main streets ; so that, in case of a ne of the main streets, the section respresented by the which the fire occurs can, by the pulling of two be completely cut off, while the cross streets on either the section will enable the lights beyond the fire or ircuit to be operated, with only the trouble of a slightly rcentage of loss, and the consequent dimming of the

e main overhead wires I must harp upon the old string, nnot be struck too often—namely, high insulation. For current work the old stand-by of "undertakers'" wire ; but when it comes to 1,000 volts difference of poten-130 or 140 amperes to back it up, one realises very hat nothing is too good to curb this fiery steed. We paying the penalty of early ignorance in having many f underwriters' wire stretched upon our poles, and I have d listened with fear and trembling to the howls of a amo which had only been in operation for a few hen we had four short circuits is as many minutes, y dead wires falling across these mains on a wet day the other hand, I have been gratified beyond expres-ce our linemen remove ten or twelve old bare iron t call" wires, which had been hanging all night right r high pressure, high insulation mains, and this during g rain. Especially should the service wires to the con-verters be of the best insulation, not only for fire but for protection to life ; for, while the shock does not kill, even a 100 volt shock may make a man start so as to fall off a ladder—and any death or injury will be credited to the electric current. We have adopted a standard of a separation of three feet between the two wires nearest each other on our cross arms, and do not allow under any circumstances the tapping of service lines directly to these wires. All services must be attached through the medium of a small spreader on the end of the cross-arm, which I have no doubt all those present have noticed on the streets.

In some districts, where the number of lights in each building is small, we run secondary low-pressure mains, and place the converters on the poles, and make our distribution from our secondary mains, but our experience has been that this is not a very satisfactory way of doing. The percentage of loss on these secondary mains, unless the wires are very large, or the converters very numerous, either of which is objectionable, causes such a decided variation in the lights as to give grounds for numerous complaints.

The question of the loss on the high-pressure feeders and mains is one which, I think, has not received enough attention. When the alternating system was first introduced, so much was said about the extreme smallness of the wire required that a great many of the arc light fiends throughout the country, who had been accustomed to congratulate themselves on the fact that No. 6 wire was big enough for a 20-mile circuit, immediately jumped to the conclusion that, because it was a high-tension current, No. 6 wire was big enough for all cases ; and, consequently, more than one case of dreadful grief has arisen. I have laid out our circuits on a certain fixed plan, which is that each circuit should be laid out for 1,300 lights (that being the size of unit which we at first adopted), and made of such sizes as to carry these 1,300 lights with a loss of not more than 2 per cent. with the load on. By having feeders large enough for this, we prevent any noticeable difference in candle-power from one end of the circuit to the other ; and should we be even compelled to run a light circuit and a loaded one on the same machine, the increase in the one or the decrease in the other would not be injurious. Of course. we try to so arrange our circuits that the load shall vary about the same on each, but the suddenness with which storms creep up in Pittsburgh makes our load very uncertain and erratic. We have run for three days and nights with only a little more than half of the machinery in operation, and then from Monday night to Friday morning have had to run every incandescent machine in the station under a load that fairly staggered it.

I now come to the question of the placing of the converters ; and for this I think you may safely lay down the general rule that wherever you are simply carrying current, do it at high pressure, and keep your low pressure for the purely local distribution. With proper precautions, I do not see that there is any real danger in carrying the high pressure wires into and through the building. If a thousand-volt current from a central station is not to be allowed in a building on account of its dangers, then every arc light plant—whether from central station or an isolated plant in the building—must be condemned for the same reason. Of course, the cases where two wires of an arc circuit, with a difference of potential of 1,000 volts, are run close together, are not nearly so many as must be the case where there is a constant difference of potential of 1,000 volts in the alternating system ; and again, of course, we have the fact that the direct current on arc circuits is generally not more than 20 amperes, while, as I have remarked before, our alternating circuits run as high as 130 amperes; but the fact that one is a direct, and the other an alternating current, largely makes up for this difference. With all due respect for the many gentlemen who have discussed so learnedly on the deadly alternating current, and on the frightful results therefrom, and whose experience with the alternating system is mostly confined to the magneto bell, or induction coil, I must maintain that the alternating current, while it is in mild doses of from one hundred to two or three hundred volts intensely more disagreeable than the direct current of the same voltage, when it comes to 1,000 volts, or more, it is very much less dangerous to life. I make this statement with the more confidence that I have tried them both ; and we have in our station here not one, but half a dozen cases where our linemen and dynamo men have received the full 1,000 volts, generally being pretty badly burned at the point of contact, but experiencing no ill after-effects ; while, whenever any of our men receive a shock from one of our arc machines they are nearly always sick for a day after. This very fact of the alternating current being more disagreeable adds to its safety, as the men are disinclined to work on the wires, even when there is only a slight leak, where with the direct current they will often take much greater risks. In carrying our high-pressure wires through the buildings, we have adopted the invariable rule that they must be carried on porcelain insulators, and the wires themselves waterproof, in all cases. We do not allow them to be run in moulding ; but where the wires are to be concealed, or protected, a casing is run around the wires outside of the porcelain insulators, giving them a perfect air

insulation, and hard rubber must always be used for floors and walls. The converters are all placed with porcelain knobs behind them, giving an air space of two inches between them and the wall; and we prefer, in all cases, to put them against brick, rather than against wood or plaster. I understand that in some districts the use of converters inside buildings has been forbidden, but I think that this position is a most unjust and untenable one. The only argument that can be brought against their being placed inside is the danger to life or of fire. For the first, the converter is well insulated, and is placed high up out of reach, and most potent argument—though one, I am sorry to say, often refused recognition—it is not placed there to be handled. As regards the danger from fire, all the converters with which I have had any experience are boxed up completely in iron cases, the only opening in which is a small one at the bottom for ventilation. They cannot possibly get hotter than the melting point of lead, for the simple reason that if they should the fuses would blow out and cut them out of the circuit, and any one who has performed the old experiment of melting lead in a piece of paper can easily see that this heat is not liable to set any thing on fire, and even should the converter burn out no flame can escape from it to set fire to anything, however inflammable. If the converter is to be banished from buildings on account of danger from fire, then every stove, high pressure steam pipe, and for that matter every gas jet must also be banished.

In a Chinese firecracker lately published I find the statement that Inspector McDevitt has relegated to the cellar all converters, and that he says that in the first case of explosion or fire from them they will have to go to the street. Now, as vice-president of the company owning these converters, I have simply to say that this is not so, and that the converters are placed all through the buildings, wherever we may desire to have them, and only three or four are in cellars. Moreover, so far from Mr. McDevitt making any such statement, he has steadily refused, even under the most urgent solicitation of the Chinese gentlemen, to make any such restriction, but has very properly stated that until an explosion or fire occurred he can take no such action. I speak of the publication as a "firecracker" for three reasons—first, because it is red; second, it is chiefly noise; third, a good many crackers are only fizzles.

As regards the liability to burn out, and the danger therefrom, I can only say that from over 600 converters of all sizes, from five to fifty lights each, in an experience extending over twelve months of constant service night and day without any stop, we have had but three actual cases of burning out, two of these being five-light converters, and one being a fifty-light converter. The two five-light converters were simply slowly roasted out from overloading, until finally the insulation on the primaries was charred through, when the fuses blew out instantly, and all was over. In one case the customer had been attracted by the converter singing, and was standing looking at it when his lights suddenly went out, and he had to go into a neighbour's store to know whether the trouble was in his lights only or with the main circuit. The fifty-light converter suffered in the same way, having nobly endeavoured for some two days to run 120 lights. It was one of three on a section of secondary mains, and the lineman who had been sent out to examine them, owing to complaint to us of poor light, reported that two of them were all right, as they were cold, but that one of them was bad, as it was very hot, and preparations were being made to change this converter, when a message was received from one of our customers that the "stove on the pole" in front of his place was smoking.

Investigation showed that both plugs in the other two converters were blown, and the only reason that this one had not followed suit was the fact that some ingenious gentleman had made them of copper. We have had three cases of defective converters—that is, converters with a wire broken inside, or short circuited, so that the moment that the current was put into them they would blow out all the fuses, and if new fuses were put in they would again blow; but the men in these cases, of course, immediately returned them to the shop for examination. That is to say, out of the 600 converters we have actually had to remove or repair 1 per cent. in actual service; and I submit that, on a total converter capacity of 17,000 lights, this is a very good proof that these converters are well made and not dangerous.

In all of our experience we have not had one single case of connection between the primary and secondary, or the primary and the shell of the converter, even in the case of the burned out converters, and we had, just a few days ago, the first case of a connection between the secondary and the shell of the converter.

We started in with the idea that it was better in cases where we had, from the number of the lights in a building, to use more than one converter, to bank them; that is to say, connect all the primaries and all the secondaries in multiple, and distribute from this 'bus wire; but two or three peculiar experiences have led us to change our plans, and never to do so if it can be easily avoided. We had two or three unfortunate cases where one converter of a bank, for some unknown reason, would blow its plugs, thus overloading the others; then, perhaps, a would give way, and thereafter it was a race as to which blow its plugs the quickest. It is not calculated to ma feel comfortable to have 400 lights in a theatre go out a just as the curtain was about four feet from the stage, beginning of the third act; yet this was our experien Christmas day. We had the converters fused up and r in half an hour, but next day the same thing occurred; the gas-man, seeing the lights dim down, was quick en shutting off his different circuits to stop three or four conv which gave him lights enough to pull through. We ha this building up, and each converter now carries its ow with the result of our detecting one of them, which, fo reason unknown, always tried to do more than its share work; but while we have marked it, we have not troul change it, as, working singly, it does its work well. W had another case of the same kind in another bank verters, which have also since been cut apart, when we the trouble arose from a poor connection, which heated fuse to melting point; yet, as we have in the City H banks of twelve 40-light converters each, and in the station a bank of twenty-three 40-light converters and 20-light converters, which have never had the current of for nearly three months, and have never had a single co of all these blow its fuses, we cannot say that this result always or even generally obtain; but as the object of b is primarily to prevent the total extinction in case of o verter going out, and this is better attained by the ju running of the secondary circuits, we prefer keeping th verters separated.

For the secondary wiring in the buildings, we need la no laws. The rules governing this are too well known any repetition. One advantage of the alternating system, was first brought to my attention by one of our wiremen fact that wires carrying the alternating system do not the surface on which they run. We have in our station of direct and alternating currents side by side, put up same time, on a ceiling painted in very light colours, and have been burning the same number of hours. The paint the direct current wires is very dirty, in the usual style, wires themselves are covered with a black deposit, wh alternating current wires, and the ceiling on which they as clean as the day when they were put up.

There yet remains one point on which I wish to sa words, and it is a subject of the greatest importance. N the alternating current distribution is a pronounced there is no reason why the places of all others where descent light is most desirable, namely, in residences, not enjoy the advantages and improvements from whic have hitherto been debarred by their distance from th centre of distribution, and it is when we bring electrici the dwelling house, where it will be daily and hourly and handled by women and children, that we realise ho lutely necessary it is that we use anything and everything can tend to make safe its introduction and manipulatic course the first, second, and third of these are—good insu better insulation, and best insulation; but besides this th other points to be considered, and one that seems to be of very careful consideration, and the fullest discussion which has been more than once suggested, namely, the of a permanent ground connection with the secondary The object of this, of course, is that should a leak occu point between the primary and the secondary, the curren already grounded will render it impossible for any one to a shock by touching the secondary, and at the same time an earth connection. When I first considered this qu said in my haste that this was not a proper course of ac one is simply provoking a ground at some other poi seeing the careful insulation of the converters we use not see any danger of a leak across; but I have since m my mind not to come to any conclusion at all until I ha sidered and heard some discussion both *pro* and *con*, and purpose I should like to hear the most bitter partisans o side, that we may get from them every little weakness o side of the question brought out.

In a paper like this it is impossible to do more than the mere sketch of the subject, but I trust that what said may be the means of inviting discussion and inquiry is only by this means that we can arrive at the true facts case, and, as we all know, the electric light industry has more than tongue can tell from the general ignorance dangers and requirements, which hindered and injured i introduction into this country, and which led to the spen so much good money on plants and wires which were not insufficient, but absolutely dangerous.

Now that we have taken, as it were, a new departu entered upon a new era of progress, let us not fall into th errors which marred the early history of our business, bu with might and main, by discussion and interchange of ence, to make each new installation another stride tow fection in what I think is undoubtedly the greatest achie of the age—the distribution of electricity by alternate c

SOCIETY OF TELEGRAPH ENGINEERS AND ELECTRICIANS—STUDENTS' MEETING.

A students' meeting was held on Friday last, the 16th inst., Mr. W. M. Mordey presiding.

Mr. Mordey made some remarks in regard to arbitrary units, and explained the system adopted by the Anglo-American Brush Electric Light Corporation for numbering wires and leads.

Mr. A. H. Dykes then opened a discussion upon transformers, which was sustained by **Messrs. Smith, Lamp, Cooper, Tidd, Collis, Zingler,** and **Mordey.**

The meeting then terminated after passing a vote of thanks to the chairman.

LEGAL INTELLIGENCE.

INFRINGEMENT OF TELEPHONE PATENTS.

A motion for an injunction on behalf of the United Telephone Company was made on March 16 before Mr. Justice Chitty, to restrain the Equitable Telephone Company from infringing the patents for telephones of the plaintiff company. The United Telephone Company being proprietors of the patents for telephones in which carbon is used, have established their right in the patent in the course of several actions, and the instruments are in general use, rented from the plaintiff company.

The defendant company was registered, with a small capital, in December, 1886, for the manufacture and sale of telephones, but they wrote to the plaintiff company, stating their intention to manufacture and sell the article, which they invited the plaintiffs to inspect at the offices of the Company, where it was fitted up. The plaintiffs took no notice of the letter. In December, 1887, and February, 1888, when the plaintiffs found the Company were at work, they bought two of the instruments, alleged by the defendants to be made according to their patent, and asserted by the plaintiffs to be an infringement of their patent. It was this instrument of which it was sought to restrain the manufacture and sale. It was said that the defendants were endeavouring to force the plaintiffs to bring another action to try over again the validity of their patent, notwithstanding the judgments already given in its favour. The defendants opposed the present motion on the ground of delay, arguing that as the plaintiffs knew in 1886 what the defendants were doing they ought to have come to the court sooner. By an affidavit of the manager of the plaintiff company it was sworn that they did not take steps against the defendants because it was thought the defendant company was a bubble company, and that the notice was only a threat; but as soon as they found the company was in active operation they brought this action.

Mr. Justice Chitty said the plaintiffs were entitled to the injunction they sought, and that there had not been delay on their part. Undertakings in damages were given by both the plaintiffs and defendants.

PROVISIONAL PATENTS, 1888.

MARCH 9.

3670. **A volt indicator.** Alexander Siemens, 28, Southampton-buildings, Chancery-lane, London, W.C.

3672. **Means or appliances for use in connection with electric circuits or water or gas supplies or the like, to enable a supply of electricity for lighting or other purposes, or a supply of water or gas, or the like, to be obtained on the deposit of an equivalent therefor in the shape of prepayment or otherwise.** Henry Edmunds, 47, Lincoln's Inn-fields, London.

3678. **Improvements in and relating to electrical signalling on railways and in apparatus therefor.** Wybrants George Olpherts, Gray's Inn Chambers, 20, High Holborn, London, W.C. (Complete specification).

3685. **Improvements in electrical switches.** Sidney Sharp, Julian Money Vernon Money-Kent, and Henry John Payne, 70, Chancery-lane, London, W.C. (Complete specification).

MARCH 10.

3690. **Improvements in railway electrical signalling apparatus.** Edward Dunn, 21, Ingestre-road, Forebridge, Staffordshire.

3710. **Improvements in electro-magnetic motors.** John Tweeddale, 87, Vincent-street, Glasgow.

3714. **Improvements in electric fittings.** Arthur Cecil Cockburn and Frank Day, Cleveland-house, Aubert Park, Highbury, N.

3766. **An improved form of communicator and collectors for dynamo-electric machines and electric motors.** George James Baldwin, 14, Carthew-road, Hammersmith, London, W.

MARCH 12.

3812. **An improved combined switch and holder for electrical incandescence or glow lamps.** Ernest Lower Berry and Gustave Franke, Gray's Inn Chambers, 20, High Holborn, London, W.C.

MARCH 13.

3841. **Improvements in telephonic apparatus.** Thomas Laurie, 115, St. Vincent-street, Glasgow.

MARCH 14.

3920. **An improved process for coating iron and steel with tin.** John Thornton, 71, Evesham-street, Redditch.

3921. **Improvements in apparatus for indicating, measuring, and controlling electrical currents.** Thomas Parker, Edmund Scott Gustave Rees and John Harold Woodward, 70, Market-street, Manchester.

3929. **Improvements in and relating to dynamo-electric machines.** Thomas Parker, Edmund Scott, Gustave Rees, and John Harold Woodward, 70, Market-street, Manchester.

3968. **Regulation of feed of arc lamps.** John William King, 13, St. John's-square, Clerkenwell, London.

3979. **Improved construction of plates and arrangement of fastenings for connecting them in voltaic order for medico-electric purposes.** William George Johnson, 166, Fleet-street, London.

3981. **Improvements in and connected with means for driving, controlling, and working electrically propelled vehicles, cranes and the like.** Edward Hopkinson, 47, Lincoln's Inn-fields, London.

3986. **An improvement in plates for secondary voltaic batteries.** Bernard Mervyn Drake and John Marshall Gorham, 28, Southampton-buildings, Chancery-lane, London, W.C.

MARCH 15.

3995. **Improvements in and relating to galvanic batteries.** Henry Harris Lake, 45, Southampton-buildings, London. (Hugo Walter, United States). (Complete specification).

3998. **An improved electrical indicator for the locking apparatus connected with railway points.** Thomas Charles Roberts Horsfield and Robert Porter, 31, Essex-street, Strand.

4008. **Improvements in electric batteries.** Harris Ullathorne and Charles Gauzentes, 20, Charles-street, Bradford, Yorkshire.

4017. **Improvements in electric arc lamps.** George Edensor Dorman, The Hawthorns, Newport-road, Stafford, Staffordshire.

COMPLETE SPECIFICATIONS ACCEPTED.

DECEMBER 11, 1886.

16,273. **Improvements in dynamo-electric machinery.** Edmond Desroziers, 47, Lincoln's Inn-fields, London, W.C.

MARCH 26, 1887.

4545. **Improvements in electrical measuring and indicating apparatus.** Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London, W.C. (The firm of Siemens and Halske, Germany).

MARCH 29, 1887.

4714. **Improved electrical signal bell apparatus for stations communicating with a single-wire telegraphic circuit.** Francis Alexandre Amoric, 28, Southampton-buildings, Chancery-lane, London.

APRIL 7, 1887.

5186. **Improvements in brush holders for dynamo electric machines.** Alexander Pelham Trotter and Walter Thomas Goolden, 23, Andulas-road, Clapham, London, S.W.

5210. **Improvements in automatic apparatus for subjecting the person to the action of electric currents.** Auguste Serrallier, 8, Quality-court, Chancery-lane, London, W.C.

MAY 2, 1887.

6409. **Improvements in dynamo-electric machines and motors.** Rookes Evelyn Bell Crompton and William Augustus Kyle, 55 and 56, Chancery-lane, London.

MAY 6, 1887.

6681. **Improvements in secondary batteries or electrical accumulators.** Rookes Evelyn Bell Crompton, Arc Works, Chelmsford, Essex, and John Charles Howell, Carffair, Llanelly.

MAY 19, 1887.

7317. **Improvements in secondary electric batteries.** James Kynoch and William Habgood, 7, Bank-buildings, Church-street, Camberwell.

JUNE 8, 1887.

8262. **Improvements in and pertaining to electric generators.** William Morris Mordey, 46, Lincoln's Inn-fields, London, W.C.

SPECIFICATIONS PUBLISHED.

1887.

2563. **Electrical primers.** G. Stuart. 8d.

2598. **Electric gas lighters.** T. P. Hewitt. 8d.

5096. **Dynamo-electric machinery.** G. Kapp. 8d.

5404. **Automatic signalling apparatus for railways.** T. H. Richardson. 8d.

5404A. **Automatic fog-signalling for railways.** T. H. Richardson. 8d.

5485. **Internal combustion thermo-dynamic engines.** J. Hargreaves. 8d.

5583. **Galvanic batteries.** H. Liepmann. 8d.

8396. **Electrical apparatus for preventing corrosion of steam boilers, &c.** A. J. Marquand. 8d.

10,057. **Extracting aluminium from its fluorides by electrolysis.** E. De Pass. (Bernard). 8d.

1888.

100. **Generating electricity.** H. H. Lake. (Humans). 11d.

623. **Thermo-electric elements and piles.** R. J. Gulcher and J. Pintsch. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼
12 Feb.	2/0	— fully paid	5	4¼
15 Feb.	10/0	Anglo-American	100	41
15 Feb.	20/0	— Pref.	100	65¾
12 Feb., 85...	5/0	— Def.	100	15
29 Dec.	3/0	Brazilian Submarine.........	10	12
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
15 Feb.	8/0	Cuba	10	12¾
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	3¾
18 Oct.	5/0	— 10% Pref.	10	9½
14 Oct.	2/0	Direct United States	20	8⅝
12 Jan.	2/6	Eastern	10	11½
12 Jan.	3/0	— 6% Pref.	10	14⅞
1 Feb.	5%	— 5%, 1899	100	105½
28 Oct.	4%	— 4% Deb. Stock	100	107½
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	12⅜
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	105
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	104½
12 Jan.	5/9	German Union	10	9¼
27 Jan.	1/6	Globe Telegraph Trust......	10	5¾
27 Jan.	3/0	— 6% Pref.	10	13⅜
3 Jan.	5/0	Great Northern...............	10	14¼

Dividend.		Name.	Paid.	Price. Wednesday.
1 Sept.	5%	Gt. Northern 5% Deb., '83.	100	105x
28 July	10/0	India Rubber, G. P. & Tel.	10	16⅜x
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
16 March ...	5%	Maxim Weston	1	3-16
15 May	5%	Oriental Telephone	11	½
14 Oct.	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2½
15 Feb.	15½%	Submarine	100	145x
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	39
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	14⅛
......	...	West African	10	5
1 March ...	5%	— 5% Debs.	100	93
29 Dec.	6/0	West Coast of America ...	10	5⅝
31 Dec.	8%	— 8% Debs.	100	116
14 Oct.	3/9	Western and Brazilian......	15	9¾
14 Oct.	3/9	— Preferred	7½	6⅝
......	...	— Deferred..................	7½	3¼
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	105
......	...	West India and Panama ...	10	13-16
30 Nov.	...	— 6% 1st Pref.	10	10½
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 Nov.	7%	West Union of U.S..........	$1,000	125
1 Sept.	6%	— 6% Sterling	100	101x

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. March 9 ...	£4,668	...
Cuba Submarine	M. of Feb. ...	3,600	+ £591
Direct Spanish......................	M. of Feb. ...	1,858	+ 235
— United States	None	Published.	...
Eastern..............................	M. of Feb. ...	51,261	+ 4,361

Name.	Ending.	Amount.	Inc. or Dec.
Eastern Extension	M. of Feb. ...	£38,795	+ £3,242
Great Northern	M. of Feb. ...	20,400	...
Submarine	None	Published.	
West Coast of America	M. of Feb. ...	4,625	...
Western and Brazilian	W. March 9 ...	3,888	...
West India and Panama	F. Feb. 29......	3,139	+ 299

Abbreviations: W., week; F., fortnight; M., month.

COMPANIES' MEETINGS.

GERMAN UNION TELEGRAPH AND TRUST COMPANY.

The seventeenth ordinary general meeting of the German Union Telegraph and Trust Company (Limited) was held on the 19th inst. at Winchester House, Old Broad-street, Sir James Anderson in the chair.

The **Chairman,** in moving the adoption of the report and the payment of a dividend (tax free) of 8s. 3d. a share, making with the previous distribution a total dividend of 14s., or at the rate of 7 per cent. per annum (compared with 6 per cent. for the previous year), reminded them of what he stated at their last meeting as to the offer of the German Government for the purchase of the Company's cable. They considered the offer somewhat favourable, but there was a good reserve, about £25,000, respecting the distribution of which they felt that they would like to know a little more. With that view, and feeling that a portion of that sum might be obtained for the shareholders, their solicitor (Mr. Burt), their secretary (Mr. Payton), and himself went to Berlin last month, and he was glad to state that after a little warm discussion they left that city about £10,000 better off. They at the same time made arrangements as to the rent of the Berlin office, the expenses of liquidation, the stamps, and, in fact, about every item that their solicitor or secretary thought was likely to dip into the reserve. They could now state with some accuracy that they believed if all went well the shareholders would receive within 1s. or 1s. 6d. of par, dependent, of course, on the expenses of repairs and breakages which might happen between now and next year. One cable was now broken, but the "Britannia" was on the spot waiting for two or three fine days to effect the repair, which he had no doubt would be easily done. After the payment of the dividend now proposed there would be no more dividend until January next, when he believed the shareholders would receive about three-fourths of their capital back, and the final distribution of capital would be in April. That was perhaps the last meeting but one of their Company. He regretted that it was to be wound up, because it was going on very well; but as the German Government would not have a private company working the traffic, they had to put up with the offer which had been made to them.

Mr. H. G. Erichsen seconded the motion, which was unanimously adopted, and the retiring director and auditor were re-elected.

CITY NOTES.

Western Union Telegraph Company.—The Western Union Telegraph Company has declared a quarterly dividend of 1¼ per cent.

National Telephone Company.—The registered offices of the National Telephone Company (Limited), will be removed on the 24th inst. to 162A, Queen Victoria-street, E.C.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company, Limited, for the half-month ended March 15, are £3,333, which compared with £3,278 for the same period last year, show an increase of £55.

Removal.—The London offices of Messrs. B. and G. Shorthouse, manufacturers of wire for telegraphic and telephonic purposes, have been removed to Mansion House Chambers, 11, Queen Victoria-street. Messrs. Applegarth and Stove, submarine and electrical engineers, are the sole London agents for this firm.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the past week amounted to £4,979, and those of the Western and Brazilian Telegraph Company, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,181.

Eastern Telegraph Company.—The Eastern Telegraph Company announce the payment, on April 14 next, of a dividend of 3s. per share on the preference shares of the Company, less income-tax, for quarter ending March 31, 1888, and an interim dividend of 2s. 6d. per share on the ordinary shares of the Company, free of income-tax, in respect of profits for the quarter ended December 31, 1887.

Direct Spanish Telegraph Company.—The report of the Direct Spanish Telegraph Company, Limited, for the half-year ended December 31, states that, after putting £2,500 of the balance of profit and loss to the reserve fund, which now amounts to £8,447, there remains £3,064 available for dividends. The directors recommend the payment of a dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend of 2¾ per cent. (free of income-tax) for the half-year upon the ordinary shares, making, with the previous distribution, 4 per cent. for the year 1887, and to carry forward £185.

NOTES.

Greece. — The Athens-Pireus-Peloponesus Railway Company has adopted the telephone for the transmission of signals on all its lines.

Indian Telegraphs.—A telegraph line is to be laid from Darjeeling to Kalimpong. A light fieldwire may also be laid onwards to the Rilli River.

International Telegraph Stations.—According to the *Journal Télégraphique* of Berne, the total number of international telegraph stations throughout the world amounts to 57,000.

Attributed to Electricity.—The recent alarm of fire at Lord Brassey's residence, 24, Park-lane, is said to have been caused by a spark from the electric converter setting fire to the wood casing.

Spain.—According to the *Industrias e Invenciones*, the Government intends to lay a new cable between Spain and the Balearic Islands. The undertaking will probably be entrusted to a foreign company.

Italy.—The Italian administration of telegraphs has superseded the Wheatstone automatic instruments by the Hughes instrument on the lines between Rome and Palermo, and between Naples and Palermo.

Paris Exhibition.—The *cahier de charges*, or conditions of contract, for the lighting of this exhibition has recently been published, and may be obtained on application to the Society of Telegraph-Engineers and Electricians, 4, the Sanctuary, Westminster.

Torquay.—Wherever they are prepared to give more money for a better light than gas or oil, there the electric light has a chance. It is about to have a chance at Torquay, where the inhabitants have resolved in public meeting to form an electric light and power company for the town.

United Telephone Company.—This company having placed six wires across the Lewisham District Board's stone-yard at Forest Hill, and having also laid some underground wires in the neighbourhood of Forest Hill Station without sanction, the Board have requested that such wires may be removed.

Electric Lighting at Mans.—A central distributing station has been opened at the Rue des Planches in this city. Crompton dynamos are employed, capable of working 2,000 Swan lamps. Scheneck and Farbaki accumulators are employed as regulators, and with a view to obviate any accidental breakdown of the lighting.

Astute Foreign Gas Companies.—At the last general meeting of the shareholders of the Reims Gas Company, full powers were given the directors to continue the negotiations already commenced with the municipality for the installation and distribution of the electric light. Similar action was taken at the last meeting of the Verona Gas Company.

Munich.—The municipality have decided to establish electric lighting in the basements of the Hotel de Ville, which comprise a large restaurant. The undertaking, which had been placed in the hands of Messrs. Schuckert, has finally been entrusted to the Electrical Company at Munich. It has also been decided not to renew the contract between the town and the gas company, which terminates in 1899.

Fire-alarm Signals.—The Stockport Watch Committee invite tenders to provide and erect fire-alarm signalling apparatus, consisting of electric bells and telephones. For particulars apply to Superintendent Buck, Police Office, Stockport. Tenders, endorsed "Tenders for Fire-Alarms," should be delivered to Mr. W. Hyde, town clerk, by 10 a.m. on the 6th prox.

Italy.—The town of Terni will shortly inaugurate its installation for electric lighting. The motive power is derived from three turbines, each of 160 h.-p., constructed by the firm of Ganz in Buda-Pesth. Each turbine will drive a Zipernowski dynamo. The present number of lamps is 300. The lighting of the Italian Exhibition, to be opened next month at Rome, has been undertaken by A. Belloni and Co., of Milan.

Batsford Park.—The stables just completed for Mr. A. B. Freeman-Mitford, at Batsford Park, have been lighted by electric light, which illuminant is also to be used in the mansion now in course of erection. The machinery is 250 yards from where the light is produced, and the current is carried by an underground cable across the park. The number of lights in the stables is 75, mostly 16 and 8 candle-power lamps.

Devonshire.—We hear that steps are to be taken to call a public meeting at Newton, following upon that at Torquay, with a view to introducing electric lighting into the town. It is pointed out as unfortunate circumstances that nearly the whole of the members of the Local Board are gas shareholders, and that the original shareholders in the gas company are getting at the present time 30 to 40 per cent. on their investment. At the same time complaint is made of the comparatively high price of gas in this locality.

The "Electrical Review."—Our New York contemporary in entering upon its 13th volume appears in what may be termed a new dress, in that its cover has a somewhat striking appearance, the front being covered by an elaborately designed illustration, indicative of the electrical industry. Our American contemporaries take credit for smart and go ahead productions, and we have no reason to complain of them on that score. The contemporary to which we have specially referred claims consideration for its enterprise, and we have no doubt it is highly appreciated by its large circle of readers.

Distribution by Accumulators.—The first central station for the distribution of the electric light by means of accumulators has recently been inaugurated at 37, Neue Friedrichstrasse, at Berlin. The installation includes two steam engines, each of 35 h.-p., and two kilo-watt dynamos. The accumulator employed is that of Khotinsky, of which each *element* (? cell) is stated to have a capacity of 600 ampere-hours. The incandescence lamps are those of Seel, taking 150 volts. The most important consumer, so far, has 500 lamps, installed in a restaurant. The total cost of the central station and main leads amounts to 89,500f., which gives 175f. per lamp.

An Electric Lamp for Farmers.—The following hint for electricians is taken from a transatlantic paper:—"Among possible applications of electricity to domestic uses there is one which does not seem to have yet attracted the attention of scientific instrument makers. That is an electric lamp for farmers. At present the husbandman in the country employs either the familiar horn lantern invented by King Alfred and a tallow dip, or the more modern glass lantern,

burning benzoline or petroleum. The former gives a wretchedly dim light, while the latter is difficult to light and extinguish, and is, moreover, very unsafe to carry about in linhays filled with straw. An electric lamp would not only give a bright light, but would be absolutely safe."

Compressed Air.—A company, with a capital of 1,800,000f., has been established at Lyon for the storage and distribution of energy by means of compressed air. Central works are to be established analogous to those in operation in the Rue St. Fargeau at Paris. This "*Compagnie lyonnaise de l'air comprimé,*" to which M. Popp is the consulting engineer, has obtained from the municipality a concession extending over forty years, during the first five of which their rights are exclusive, for the house-to-house distribution of motive power. It seems improbable that this company will obtain a greater measure of success than has been realised by the Paris establishment; in other words, their outlook is not very encouraging.

Bournemouth.—At a recent meeting of the Roads Committee a letter was read from Messrs. Phillips, Harrison, and Hart, asking permission to lay down their cables along the roads. It was recommended that a committee of the whole board be called to consider the matter. The Clerk, at the recent meeting, read another letter from the same firm, stating that they only required immediate permission for taking up the roads leading from the Arcade and Town Hall-avenue to their works in Orchard-lane, and that they would like to be allowed to transfer the permission to the Bournemouth Electric Light Company, which was recently formed. The recommendation to refer the former application to a committee of the whole board was agreed to, and the latter question was similarly dealt with.

Conductivity of Nitric Acid.—It has been shown by M. Bouty that the addition to fuming nitric acid of very minute proportions of an alkaline nitrate has the effect of considerably augmenting the electrical conductivity of the liquid. Continuing his researches in this direction, the same investigator points out that, up to a certain point, the addition of water to the concentrated acid increases its conductivity almost in the proportion of the quantity of water added. The addition of small proportions of dehydrating substances, such as concentrated sulphuric acid or anhydrous sulphurous acid, has the same effect, apparently by reason of the production of electrolytic compounds of sulphuric or phosphoric and nitric acids. Lastly, M. Bouty has demonstrated that nitric acid in different stages of dilution does not contain the same electrotype.

The Van Rysselberghe System in Switzerland. This system of rendering a wire adaptable for the simultaneous transmission of telegraphic and telephonic messages, by an application of the law of electro-magnetic inertia, has not hitherto been a success in Switzerland; and the results there obtained render it questionable whether it has in reality proved successful elsewhere. The system was adopted experimentally by the Swiss Government on the Bâle-Zurich line, and the results are stated to have been so unfavourable that the idea of applying it to other lines has been relinquished, and, in spite of the large expense involved, it has been decided to establish special lines for inter-urban telephony. Moreover, the establishment of this means of communication between Bâle and Zurich, in substitution for the Van Rysselberghe arrangements, is under consideration.

Pender and Co.—"We have been waiting to see some protest against the proposed banquet to Sir John Pender. Sir John Pender is an expert and successful cable jobber, and as cable jobbing is a business that conduces to the prosperity of the jobbers, by all means let them dine each other. But when a pretence is made that a scientific interest attaches to such a gathering we enter our objection. With the view of getting a representative meeting together, invitations to the banquet have been sent out broadcast to all sorts of scientific men, several of whom have written to us saying that they have nothing whatever to do with the affair. The promoter appears to be Sir James Anderson, whose profession coincides very largely with that of Sir John Pender. Well, let Sir James Anderson and Sir John Pender drink each others' healths if they will, but do not let us have speculation masquerading in the guise of science."—*Star.*

Bremen.—The authorities of this town have entered into an arrangement with the "Allgemeine Elektricitaets Gesellschaff," of Berlin, for the installation of a central station for the supply of the electric light. In consideration of an annual payment of 1.25fr. for each lamp worked from the station, the town has conceded to the Company the right to establish overhead or underground wires in the streets as it may think fit. The subscribers will pay about 5½ centimes per hour per lamp of 16 c.-p. The station will be capable of working 10,000 lamps. The subscribers are to defray the cost of the lamps and of the installation in their houses; but the Company reserve the right of refusing to supply any subscriber whose installation has not been carried out by Messrs. Siemens and Halske, to whom the execution of the work has been entrusted. The same Company possesses at Hamburg a small station supplying 1,500 incandescence and several arc lamps.

Electric Railway.—A project, which has obtained the approval of the *Conseil d'Etat*, has been mooted for the construction of a "rack and pinion" electric railway, about 6 kilometres in length, between the village of Etrembières, in Savoy, and the plateau of Grand Salère, from which the view extends on one side to Geneva, the Jura, and Leman, whilst on the other it embraces the panorama of the great Alps. This project is of interest, not only to the localities to be traversed, but also to the City of Geneva, and to the tourists of all nationalities who flock thither every year. One of the clauses of the agreement stipulates that the concessionaires are to supplement this line, when constructed, by another starting from Veyrier, and ascending the Swiss slope by the passage known as the Pas-de-l'Echelle. This would obviate the inconvenience to the inhabitants of Geneva and to tourists of having to travel a considerable distance to the Etrembières terminus in order to ascend to the Salère by the railway.

Railway Carriage Lighting.—Since the commencement of the year, experiments have been made on the State railways in Alsace on the electric lighting of the trains. The current is supplied from a small battery of accumulators situated beneath each carriage. Each battery consists of 36 couples; and the batteries are charged at several stations supplied with an installation for lighting, which is thus utilised during the daytime. The capacity of the batteries is 40 ampere hours—presumably under an E.M.F. of 72 volts. No details are given as to the weight of the batteries. The plates are said to be constructed with a frame of lead carrying a certain number of vertical lead rods about 3 millimetres in diameter, expanding at intervals into the form of a thin disk about 9mm. in

diameter. Each carriage is lighted by 5 Seel lamps of 10 c.-p., taking under 60 volts a current of from ·5 to ·6 ampere. The conductor of the train can regulate the light by means of a small resistance-coil in the vicinity of the battery. The work has been carried out by the Société Alsacienne d' Electricite at Strasbourg.

Electric Lighting of Trains.—On Tuesday morning a number of gentlemen interested in the lighting of railway carriages by electricity left St. Pancras Station by the ten minutes past ten train, on the invitation of Mr. John Noble, managing director of the Midland Railway Company, to visit Derby, and to witness the working between that town and Manchester of the system of electric lighting of railway carriages patented by Mr. J. A. Timmis. The chief feature of the system is that it secures "through lighting" in a train by the adoption of the Union battery stored in each vehicle, and by this means any carriage may be put into a siding, or be slipped from a train without interfering with the maintenance of the light. In case one or more of the vehicles are slipped or break loose from a train, the lamps in them, if lit, remain lighted, and if they are not lit provision is made for their being automatically lighted up. The chief feature of the arrangement is in what is termed the controlling circuit, by means of which the guard can switch the lights on or off at will, though at all times the state of the lighting circuit is such that, should a carriage break away, the lamps are automatically lighted. The lamps used are 5 candle-power Swan lamps, two to each carriage, and these are arranged below reflectors, that aid in the equal distribution of light through the whole carriage.

The Burning of the Oporto Theatre.—Our apprehension as to the probable extent of the loss of life, consequent upon the destruction by fire of the Baquet Theatre, has been only too fully confirmed. The number of bodies exposed for identification amounted to sixty-six, and besides these there were fifty-three unrecognisable masses, which could be distinguished as human remains, and for the reception of which the municipalty is constructing a marble mausoleum. The electric light has been utilised to enable workmen to continue their search for bodies by night as well as by day. The account given of the origin of the catastrophe sounds horribly familiar to our ears :—"So far as can be ascertained, this disaster arose from an unprotected jet of gas being blown by a draught against the scenery. A scene-shifter named Davas saw it, and tried to lower the curtain, so as to shut out the flames from the auditorium, but as he was rushing forward some burning scenery fell down on the stage. The public became panic-stricken, and made a simultaneous and violent rush for the doors." The theatre was formerly a circus, and was constructed mainly of wood. Of course, "the gas went out suddenly," and in the narrow passages the fresh terror and danger of darkness fell upon those who had struggled beyond the glare of the flames. Is it too much to hope and to expect that a similar catastrophe will never again be due to the selfsame cause ?

Encyclopædia Britannica.—The current volume of the Encyclopædia Britannica contains several very interesting articles to electricians. The longest and more important ones are those contributed by Mr. T. Gray, who is now contributing to our own columns, on the telegraph and telephone. In the former the author first gives an historic sketch of early telegraphs, mentioning the several people who suggested the various forms of telegraphs actuated by static electricity, and we are glad to see that the brothers Highton are mentioned. The work of these gentlemen is frequently overlooked. Then we have a general description of electric telegraphy for land and sea, followed with the various tests employed, especially in cable work, concluding with a description and explanation of the instruments used in modern telegraphy, such as the Morse instrument, the Hughes type-printing, and briefly referring to duplex and quadruplex work so far as land working is concerned. Nor are the beautiful instruments of Sir William Thomson used in telegraphy overlooked, but are sufficiently explained, so that the casual reader may understand the principles upon which their actions depend. The method pursued in the article on telephony is somewhat similar to that pursued on telegraphy, giving first a brief historic *resumé*, then describing the various instruments and their improvements somewhat in the order of their invention, concluding with a discussion on telephonic circuits and the method of working their circuits. Altogether Mr. Gray has contrived to get a very considerably amount of interesting information into a comparatively small space.

The Central Station at Saint-Etienne. — According to the *Bulletin International de l'Electricité* the gas company at Saint-Etienne has taken proceedings against the municipality of that town in relation to the establishment there of a central station for electric lighting. This action, however, has had no detrimental effect upon the new undertaking ; indeed, the uninterrupted flow of applications from intending subscribers has necessitated a considerable augmentation of the plant. The initial installation comprised four Edison dynamos of 400 amperes ; the number has now been increased to seven, of which one is maintained in reserve, the remaining six being arranged in three groups of two in series. These are capable of supplying 3,000 lamps of 16 c.-p., which actually corresponds to a considerably greater number of lamps, since many of these are of 10 c.-p. only. The three-wire system of distribution is to be adopted ; and the cables formerly employed are to be replaced by bars of copper ; the three bars in each group of conductors being kept apart by insulators of dried and bitumenised wood and inserted in iron pipes, which are afterwards filled with a melted mixture composed of 70 parts of asphalte, 15 of paraffin, and 18 of rosin. The motive power disposable at the Saint-Etienne works is at present 600 h.-p. ; it is supplied from four steam engines each of 150 h.-p., and would be capable of supplying 6,000 lamps of 16 c.-p. The financial results of the undertaking promise to be of a satisfactory character, although no dividend has yet been declared. The works have been in partial operation since January, 1886.

Incandescent Lamps.—Mr. Hosea E. Husted, in the *Electrical World*, writes on the subject of why lamps blacken. He says :—"In considering the above question, and as the result of experiment, I have come to the following conclusions : First, if we take an incandescent lamp globe and fill it two-thirds full of a mixture of equal parts of turpentine, alcohol and benzine, and seal up the opening, then heat it to 100deg. F., and let it stand, we will find the oil will ooze out of the pores. The reason of this is that in heating, the glass globe expands and lets the thin oil through the pores. In manufacturing these globes the filament is placed in them and the air is extracted, creating a vacuum. Without this the carbon would be consumed the instant the electrical current passes into it.

After a time a black deposit will be noticed upon the inner surface of the globe, due to a separation from the filament. If a globe that is blackened be jarred, it will emit sounds as of two pieces of steel struck together. These sounds are due to the presence of air in the globe, as the following experiments will prove: Place a bell under a globe, create a vacuum by a pump and try to ring the bell. The armature will vibrate and strike the bell, but no sound will be emitted. Now, allow a small quantity of air to pass in and the sound will gradually increase as the air is admitted. Hence, I conclude, that by heat and atmospheric pressure the vacuum has ceased to exist in the globe, and by the presence of air the carbon is consumed, giving off a gas or vapour which is deposited upon the glass and blackens it." We cannot say that we agree with all the conclusions of the observer we have quoted.

More Light.—Looking back nearly a century and a half, our contemporary *Electricité* takes note of the continuously increasing demand for a higher degree of illumination—a demand which has only recently met with anything like a corresponding supply. In 1745, on the occasion of a festival given in the *Salle des Glaces*, at Versailles, the guests were fain to content themselves with a lighting effect corresponding to 2·5 candles per cubic metre, or 0·19 candle per square metre of plane surface. In 1788, in the *Salle des Fêtes* at Compiègne, a less lofty hall, the illumination had been raised to 2·3 (?3·6) candles per cubic metre, corresponding to 0·28 candle per square metre. In 1873 and 1878, in the same hall of the Graces, the lighting was increased respectively to 8·3 and 16·7 candles per cubic metre, or to 0·64 and 1·30 candle per square metre. Within a century, therefore, the illumination has been augmented more than six-fold. In the electric lighting of the grand opera, the illumination of the *foyer* was 11·3 candles per cubic metre or 0·63 candle per square metre. Taking the mean illumination, this amounts to 4 carcel metres or about 30 candle metres. This means that on any surface, taken in any direction, the illumination is the same as would be given by the concentrated light of 4 carcel burners at a distance of a metre. This was excessive, or at least relatively so; for the theatre itself, in which it was impossible to produce such a flood of light, seemed dark by contrast, and for this reason the former illumination has been diminished. At the *Hôtel de Ville*, during the festivals of the present year, the illumination, which in the *salon de verdure* and reserved hall was only about 4·4 candles per cubic metre, was raised to 14 and even 15 candles in the *salle des fêtes*, the dining room, the grand saloons and the side gallery.

Electro-Harmonic Society.—A smoking concert is announced for Friday, April 6, 1888, at the St. James's Hall Restaurant (Banquet Room), to commence at eight o'clock. The artistes are Mr. Robert Hilton, Mr. Arthur Thompson, Master Humm; elocutionist, Mr. Charles Fry; violins, MM. Jacques Greebe and T. E. Gatehouse; viola, Mr. W. Hann; violoncello, Mr. W. C. Hann; solo pianoforte and accompanist, Mr. Alfred Izard. The following is the programme:—Part I.: String quartette, "Allegro Moderato" (minueto and trio) (Hadyn), MM. Greebe, Gatehouse, W. Hann, and W. C. Hann; new song, "Oft I Wander" (Lovett King), Mr. Arthur Thompson; recitation, (*a*) "The Glove and the Lions" (Leigh Hunt), (*b*) "A Tragedy in Five Acts" (Anon), Mr. Charles Fry; song, "Nymphs and Shepherds" (Henry Purcell), Master Humm; duet for two violins, "Introduction and Rondo" (Kalliwoda), Mr. T. E. Gatehouse and Mr. Jacques Greebe, piano Mr. Alfred Izard; recit. and air (*La Reine de Saba*), "She alone charmeth my sadness" (Gounod), Mr. Robert Hilton; string quartette, "Andante Cantabile" (Mozart), "Minuetto and Trio," "Allegro Moderato," MM. Greebe, Gatehouse, W. Hann, and W. C. Hann.—Part II.: Duet for two violins, "Schlummerlied" (Ch. Ersfield), Mr. T. E. Gatehouse and M. Jacques Greebe, piano Mr. Alfred Izard; song, "The Sands o' Dee" (F. Clay), Mr. Arthur Thompson; recitation, "The Gridiron" (S. Lover), Mr. Charles Fry; song, "The Diver" (E. J. Loder), Mr. Robert Hilton; piano solo (selected), Mr. Alfred Izard; song, "The Children's Home" (F. H. Cowen), Master Humm; string quartette, "Adagio Cantabile" (Haydn), "Finale Vivace," MM. Greebe, Gatehouse, W. Hann, and W. C. Hann.

The City Lighting.—The following suggestion is made by our contemporary the *Journal of Gas Lighting*. It is good as far it goes; but, of course, practically assumes there is a sufficiency of light from existing gas lamps. We, on the contrary, contend there is a deficiency. Here is what is said:—"It is to be supposed that the Streets Committee of the Commissioners of Sewers of the City of London are still deliberating upon the details of the competitive offers of electric light companies for lighting the City streets, which are generally believed to have been submitted to them. It should not be asking too much to request the Committee, before going any further in this matter, to appoint a Technical Commission, consisting (say) of their own engineer (Mr. W. Haywood, M.I.C.E.) and gas examiner (Mr. C. Heisch, F.I.C., F.C.S.), with an independent authority, to draw up a report upon the general question of the lighting of the City thoroughfares. The matters which could be referred to such a body might be the cost and efficiency of the existing method of lighting the streets. They should ascertain the actual amount of light afforded by the gas-lamps in use, and give their observations upon its sufficiency or otherwise from the points of view of public security, traffic, and trade. They might compare the lighting of the City with the public lighting of other busy centres of trade. The requirements of different thoroughfares as affected by the nature and course of traffic, the number and character of crossings, the amount of extra illumination from shop windows, and the time of closing business establishments, should also be taken note of. Then, if an increase of light is found desirable anywhere, the best and cheapest way of providing it would be shown by comparisons in which reliable photometry and true figures would be used. The result of the labours of such a commission would be to settle the data upon which contracts for new systems of lighting may be safely based. The practice actually in vogue is the contrary of this plan, being merely to receive suggestions for supplanting so many gas-lanterns by electric lamps, without anybody knowing whether the change is likely to result in better or worse lighting for practical purposes. There is not much probability, however, of this suggestion being adopted, because it is too sensible."

Lighthouses and Coastguard Stations.—The *Western Morning News* publishes a letter from Mr. J. G. Uren, of Penzance, which strongly urges the necessity of bringing the above within speaking distance:—"Ever since the loss of the 'Schiller,'" says Mr. Uren, "I have been endeavouring to impress on the public the extreme importance of having our lighthouses and coastguard stations

connected with the telegraph system of the country. Above all, I earnestly protest against the matter being looked upon solely in its financial aspect. It is easy enough to show that no direct return could be had for the capital expended. The same may be said of our troops and our warships, our guns and our fortresses. Yet nobody advocates that the country should be left defenceless. So in this matter is it nothing to avert disaster? to aid in the saving of life and property? and to protect our coasts from Scilly to the Hebrides with a cordon of sentinels in touch with the great arsenals of the kingdom, and ready at any moment to direct our efforts on any point which may be threatened by an enemy? Suppose it does cost a million or so—not millions but tens of millions have been spent in far less worthy causes—and are we to be told that a great maritime power like England, whose supremacy depends on the command of the sea, is to shrug its shouulders and raise the cry, 'it won't pay,' when even our colonies are setting us the example, and other countries with not a tithe of the interests at stake are showing us the way? I hope it is not necessary to give any further examples of the utility of this great work, but I cannot help referring to the case of the Brixham trawler lost off the Gurnard's Head last week. She was seen to be in distress, with the crew at the pumps, and one hand lashed to the mast. She was followed from point to point, and foundered, in fact, within view of many who would have been only too glad to render assistance had the appliances been at hand. There was a lifeboat and rocket apparatus on either side of her—at Sennen and St. Ives—yet neither was aware of her danger. Intermediately, at Pendeen and the Gurnard's Head, there are coastguard stations, and in all human probability, had they been able to communicate promptly with their brother officers at Sennen and St. Ives, five valuable lives would have been saved. This is only a solitary instance of what is going on round our coasts year after year."

Taunton and Exeter.—The following letter appeared in the *Exeter Gazette* recently, in reply to an article which appeared in that paper, copied from the *Gas World*, severely criticising the Taunton Electric Light Company :—Sir: Owing to absence from home, I have only just received a copy of your paper of the 13th inst., containing a criticism of the Taunton Electric Light Company, copied from the *Gas World*. I was certainly astonished that even a journal devoted to gas interests should make so inaccurate and misleading a statement. As I see by your issue of the 14th inst. that Mr. J. Knill has kindly supplied your readers with the correct figures, I will not trouble you with them. The annual reports and balance sheet of the Taunton Company have been audited by a gentleman who commands the respect of all who know him. He is a director also of the rival lighting Company (the Taunton Gas Company). Copies of these reports have been freely circulated in Taunton, and it would appear that each of the journals devoted to gas interests has obtained one, judging from the opportunities they appear to have for criticising. But they have been obliged to bless where they intended to curse, for in each instance their condemnation is in reality commendation. The only fault they can find with the Company is that its costs of management are too small, and that had its officers been paid on an extravagant scale instead of an economical one, it would have been unable out of its nett income to pay a dividend of 5 per cent. per annum upon the whole of its share capital, and carry forward a balance equal to an additional 2 per cent. I admit that "An Electric Light Company earning a dividend of 5 per cent. upon the mere supply of lights is a curiosity in this country, and in this respect occupies an exceptional position." But I must remind *Gas World* that there must be a beginning to everything, and the experience of the pioneer gas companies differs very little, if at all, from that of the pioneer electric light companies. I certainly feel complimented by the statement of *Gas World* that "the Electric Light Company in Taunton would, in all probability, have gone the way of other similar Companies but for the Herculean efforts of Mr. H. G. Massingham, who assumes the function of managing director." As I have accepted a similar position with respect to the Exeter Electric Light Company, I trust that my efforts will be no less "Herculean" on behalf of that Company also, and that they will be attended with the same happy results to the shareholders.—I am sir, yours, &c., H. G. Massingham. Bath, March 17th, 1888.

The Proposed Central Stations in Paris.—The obnoxious *cahier des charges*, or conditions of contract, relative to the construction and working of central distributing stations in Paris, is still under the consideration of the Municipal Council of that city. It is understood that its adoption would have the effect of almost precluding all enterprise in the direction of electric lighting; and, amongst the projected undertakings of which it would effectually prevent the execution, are the following, which are referred to in the report of M. Lyon-Alemand to the Electrical Committee :—The Continental Edison Company have put forward a proposal to establish a canalisation, extending from its works at Ivry to the Place de l'Opera, *viâ* the Rue de Patay, the Rue Jeanne d'Arc, the Rue Geoffroy-Saint-Hilaine, the Boulevard St. Germain, the Boulevard Saint-Michel, the bouleuard de Sébastopol, and the grand boulevards, returning by the Rue de Rivoli; these mains serving also for the production of the light in the Place de la République and the Rue de Turbigo.—The electric apparatus and lighting company (Cance Company), the central works of which are situated at 7, Rue du Faubourg Montmartre, proposes to supply the grand boulevards, from the Rue Mazagran to the Rue de la chausseé d'Antin, together with the surrounding streets, as far as the Rue Cadet, the Rue Geoffroy-Marie, and the Rue Sainte-Cécile, inclusively, in one direction, and as far as the Bourse in the other direction.—The French Company of Electric Lighting (Mildé and Clerc) proposes to extend its network from the Porte Saint-Martin to Place de la Madeleine, including in its operations a portion of the Boulevard de Strasbourg, of the Boulevard de Sébastopol, and of the Faubourgs Saint-Martin and Saint-Denis, a portion of Rue Montmartre, the Rue du Faubourg Montmartre, and the surrounding streets, and, lastly, the district surrounding the Opéra.—M. Pulsford applies for a concession over 774 metres of the Boulevard de Strasbourg, the Boulevard Saint Denis, the Rue du Faubourg Saint Martin, and the Rue du Château d'Eau.—Lastly, the company for the electrical transmission of force (M. Marcel Deprez) proposes to establish its leads from the *gare du Nord* to the Grand Hôtel, *viâ* the Rue Lafayette and the Rue de la Chausseé d'Antin; connecting this line through the grand boulevards to another line supplying the *Bourse du Commerce*, and passing through the Boulevard de Magenta, the Boulevard de Strasbourg, the Boulevard de Sébastopol, and the Rue de Turbigo.—To the above might be added the proposed municipal works in the basements of the Halles, which, besides supplying the market buildings, was to light the Hotel de Ville quarter.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 248.*)

Calibration of Wires.—It is not always possible to obtain wires of perfectly uniform section, and it is still more difficult, when alloys like German silver or platinoid are used, to obtain wires of perfectly uniform electrical resistance. It is important therefore to have some ready means of testing the electrical uniformity of the wires to be used for the wire slide in a Kirchoff's or similar bridge. The following method will be found convenient and sufficiently accurate for a preliminary test of the wire before it is soldered into the bridge. Let W, Fig. 14, be a piece of the wire to be tested. Join it between two binding screws A, B, or solder it to the heads of two wood-screws fixed in a table or piece of board. Connect up in circuit with the wire a battery E, introducing into the circuit a key or break-circuit plug P. On one side of a block of dry or paraffined wood, or vulcanite, C, fix two springs *a*, *b*, five or ten centimetres apart, measured between two knife edge contact pieces soldered on the lower sides of the springs. Cut a narrow V groove parallel to the edge of the block C, and place the edge of the block far enough under the wire to allow the wire to rest in the groove, with the contacts attached to the springs resting on the top of it. Join the electrodes of a high resistance and sensitive galvanometer, G, to the two springs, *a*, *b*, and note the zero of the galvanometer. Close the circuit of the battery, E, and note the deflection of the galvanometer after it has become constant.

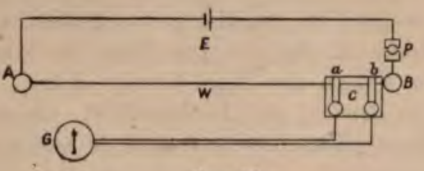


FIG. 14.

There will be a slight variation at first, due to the heating of the wire by the current. Then slide C slowly along the wire, and observe whether there is any change of deflec tion. If there is no change, the wire is so nearly uniform that this method is not sensitive enough to show the variations. If there is a change, the wire may be calibrated by noting the galvanometer deflection at different points along the wire. The curve of variation along the wire can be clearly shown by plotting the results of the experiment on section paper, divided, say, to tenths of an inch, and drawing a smooth curve through them. Suppose, for example, that the deflection of the galvanometer was about 500 scale divisions, and that it varied a few divisions backwards and forwards; we may take any line on the section paper for the 500 line, and using one division of the paper as one scale division plot the *variation* from 500 above and below the line, using for abscissæ lengths along the wire from one end, reduced to a convenient scale. The sensibility of the method here indicated may be increased either by increasing the current through the wire, or by increasing the sensibility of the galvanometer, and using what has sometimes been called a "false," and sometimes an "inferred," zero for the galvanometer. In this method the deflection of the galvanometer needle is brought approximately to the zero of the scale by means of a permanent magnet, placed with its length horizontal and at right angles to the length of the needle when in its zero position. This is equivalent to deflecting the needle when no current is flowing off the scale in the opposite direction from that in which the current deflects it. The effective zero may be inferred by varying the distance between *a* and *b* by a measured fraction of the total distance, and observing the change of deflection. This change of deflection will be the same fraction of the total deflection as the change of distance between *a* and *b* is of the total distance between them. The deflection may be reduced to zero by means of a coil placed with its plane parallel to that of the galvanometer coil, either the position of the coil, or the strength of the current through it, being varied until zero deflection is obtained. The current through this second coil may be obtained either from an independent battery, or, which is better, it may be obtained from a different part of the wire which is being calibrated. This method of compensation suggests at once a differential galvanometer as a convenient instrument for the test. The electrodes of one coil of this galvanometer should be connected to two points near A or B, and the same distance apart as the contacts of the springs *a* *b*. For use in this way it is very convenient to have one of the springs *a* or *b* mounted on a fine screw, by means of which the distance between the contacts can be varied. The total value of the deflection, which would be obtained if the current through coils connected to *a* and *b* alone flowed, can then be found by turning the screw through such a distance as to give a convenient deflection. If the displacement of the spring due to turning the screw be d_1, the total distance between the contacts d, the deflection due to turning the screw D_1 and the total deflection D, then

$$D = D_1 \frac{d}{d_1}.$$

The slider may then be drawn along the wire and the deflections noted, and put down in the form of a curve as indicated above, or the deflections may be always reduced to zero by means of the screw, and the percentage variation of the wire estimated from the step and number of turns of the screw and the total distance between the contacts. It is, as a rule, quicker, and quite as accurate, to leave the screw fixed and read the galvanometer deflections.

The following method of calibrating a wire has been

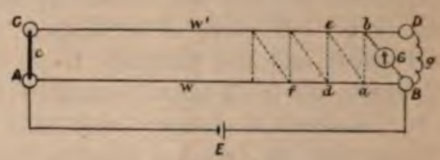


FIG. 15.

described by Prof. Carey Foster, and is commonly known as Foster's method. It is intended to divide a wire into sections of equal resistance, and it is capable of doing so with great exactness. Let w be the wire to be calibrated. Connect it in series with a battery E, as shown in Fig. 15, and arrange a second wire w_1 in a convenient position relatively to w, so that the two wires may be connected in parallel by means of the connecting pieces g and c. The resistance g is called the gauge, and it is convenient for it to be a definite fraction of the resistance $w_1 + g$, say a tenth of that resistance. The connecting piece c generally has, and is here assumed to have, so small a resistance that it is negligible compared with g. The connections should be made by means of mercury cups at A, B, C, D, so as to avoid error due to resistance at these points. The mode of operation is as follows:—Connect one electrode of a galvanometer, G, to the mercury cup D, and find the point a on w at which, when contact is made, the galvanometer needle is not deflected. Next keep the contact at a and interchange g and c and then find the point b on w_1 at which, when contact is made, the galvanometer shows zero deflection. Proceed in this way by interchanging g and c and finding alternately points on w and w_1, as indicated by the dotted lines in the figure, until the end of the wire, w, has been reached.

It is clear that the successive steps along w and w_1 are equal; because, after balance has been obtained with the galvanometer connected from D to a a resistance of $g - c$ is transferred to the other end of the bridge, and hence a resistance b D equal to $g - c$ must be passed over before balance can be again obtained, and this is the case for each step along w_1, hence w_1 is divided with equal steps. Again, a B is the same fraction of A B that g is of $c + w_1 + g$, and d B is the same fraction of A B that $b\,D + g$ is of $c + w_1 + g$, that is, since $b\,D = g$, when c is negligible, d B is twice a B, and so on. When $g - c$ differs sensibly from g, the first

B is greater than the succeeding ones, and for that it is generally preferred to make w_1 the wire to be ;ed. There is, however, the advantage in the here indicated that c_1, w_1, and g, may form of a permanent piece of apparatus for the e, and w_1 may be made of comparatively high ice either by making it a thin wire or by doubling al times backwards and forwards, gridiron like, and aking it long. The gauge g can then be made of esistance that if c be a thick U of copper its resis- nay be neglected. In carrying out this method care e taken that the ends of g and c are clean and well mated, and that they make contact directly on the of the cup so that no mercury resistance is inter- The ends of g should be thick pieces of copper so y variation in the quantity of mercury in the cups ot affect the resistance. The continual interchange d c is apt to lift globules of mercury out of the cups read them over the board on which the wires are ed, and care must be taken that these do not touch es if they are of a material that amalgamates with y.

following modifications of Foster's method possess antage that no mercury cups need be used, and the s in the wire circuits are all permanently made and e soldered. Let w, Fig. 16, be the wire to be ted, and w_1 an auxiliary wire Connect the ends C, either directly, or by means of a connecting piece the ends B and D by means of a small resistance- g. Put one of the battery electrodes to A, and the to the lever of the key K, and the front and tops of the key to the points B and D respectively. ans of the key K the battery may be put to B or D

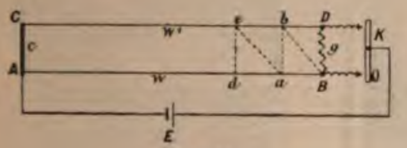


FIG 16.

will of the operator, the resistance of the connecting and the key contacts being always in the battery With the battery to D, and one electrode of the ometer to B, find the point b which has the same ial as B. Then, with the battery to B, and one elec- f the galvanometer to b, find the point a which has ne potential as b, and so on. The steps along A B , in this case, equal to each other, but they have a nt ratio; and hence, if it is simply the uniformity of e which is to be tested, this method serves the pur- erfectly. If it is desired to divide the wire up into s of equal resistance, it may be done by calculation he results of this experiment; but a more convenient for this purpose is described below. It should be bered, in the practical use of this method, that the is first put to the end of the wire to be calibrated; is not done, the first step is not in the regular series he others. Thus b D, together with the gauge g, form st step of the series along w_1. The relative values of ferent steps along either of the wires may be readily as follows: Let $x_1, x_2, x_3, \ldots$ be the successive steps w, and $y_1, y_2, y_3, \ldots$ those along w_1; and let the re e of w and w_1 be R and R_1 respectively. Then we y Ohm's law, or by the ordinary Wheatstone's bridge la,

$$\frac{y_1}{R_1 - y_1} = \frac{g}{R} \text{ or } y_1 = \frac{R_1}{R+g} g \quad . \quad . \quad . \quad (1)$$

n the same way we obtain

$$+y_2 = \frac{R_1}{R+g}(g+x_1). \quad \therefore \text{ by (1) } y_2 = \frac{R_1}{R+g}x_1 \,.\, (2)$$

$$y_1+y_2+y_3 = \frac{R_1}{R+g}(g+x_1+x_2).$$

$$\therefore \text{ by (1) and (2) } y_3 = \frac{R_1}{R+g}x_2 \quad . \quad . \quad (3)$$

c.

Similarly we have

$$\frac{x_1}{R - x_1} = \frac{y_1+g}{R_1 - y_1} \text{ or } x_1 = \frac{R}{R_1+g}(y_1+g) \quad . \quad (4)$$

$$x_1 + x_2 = \frac{R}{R_1+g}(y_1+y_2+g) \;\therefore\; \text{by (4) } x_2 = \frac{R}{R_1+g}y_2 \quad (5)$$

$$\text{Hence by equation (2) } x_2 = \frac{R\,R_1}{(R_1+g)(R+g)}x_1 \quad . \quad (6)$$

$$x_1 + x_2 + x_3 = \frac{R}{R_1+g}(y_1+y_2+y_3+g).$$

$$\therefore \text{ by (4) + (5) } X_3 = \frac{R}{R_1+g}y_3.$$

$$\text{Hence by equation (3) and (6) } x_3 = \left\{\frac{R\,R_1}{(R_1+g)(R+g)}\right\}^2 x_1 \;(7)$$

&c., &c. Hence we have

$$\frac{x_1}{x_2} = \frac{x_2}{x_3} = \frac{x_3}{x_4} = \text{\&c.} = \frac{y_2}{y_3} = \frac{y_3}{y_4} = \text{\&c.} = \frac{(R_1+g)(R+g)}{R\,R_1} \quad . \quad . \quad (8)$$

From equation (8) we see that the length of these successive steps along the wire w and, with the exception of the first, along w_1 form a geometric series having the common ratio $R\,R_1 / (R_1+g)\,(R+g)$. The proper value of this fraction and the uniformity of the wire can be readily found by plotting the results in the form of a curve in a similar manner to that explained above.

In order to obtain steps of equal resistance along the wire by this method two gauges g of equal resistance are used to connect the two ends of the wires w and w_1. A

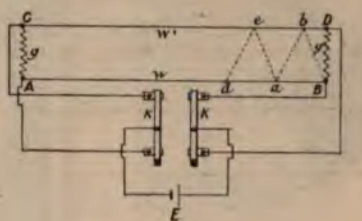


FIG. 17.

convenient arrangement for the purpose is shown in Fig. 17. Two keys, K and K_1, are placed side by side, and the battery is connected to the levers as shown. The front stop of K is connected to C, and the back stop of K_1 to D, and, in the same way, the front stop of K_1 is connected to B, and the back stop of K to A. Thus, when the levers of the keys are similarly placed, the battery is either joined across from C to B or from A to D. Join it in the first place from A to D, and find the point b which has the same potential as B, then join it from C to B, and find the point A which has the same potential as b, and proceed in this way until the point A is either exactly or nearly reached. The resistances from B to a, a to d, &c., will be all equal. Let, as before, the resistances of the successive steps along w be x_1, x_2, x_3, &c., and those along w_1 be y_1, y_2, y_3, &c.; and let the resistance of the wire w be R, and that of w_1 be R_1. Then we have

$$\frac{y_1}{R_1 + g - y_1} = \frac{g}{R}; \text{ or, } y_1 = \frac{R_1+g}{R+g}g \quad . \quad . \quad . \quad (1)$$

$$\frac{y_1+y_2}{R_1+g-(y_1+y_2)} = \frac{g+x_1}{R-x_1}.$$

$$\therefore y_1+y_2 = \frac{R_1+g}{R+g}(g+x_1), \text{ and by (1) } y_2 = \frac{R_1+g}{R+g}x_1 \;.\; (2)$$

&c., &c. Similarly we have

$$\frac{x_1}{R+g-x_1} = \frac{y_1+g}{R_1-y_1} \text{ or } x_1 = \frac{R+g}{R_1+g}(y_1+g) \quad . \quad . \quad (3)$$

$$\text{Hence by (1)} \quad x_1 = g\frac{R+R_1+2g}{R_1+g} \quad . \quad . \quad . \quad . \quad (4)$$

$$\frac{x_1+x_2}{R+g-(x_1+x_2)} = \frac{y_1+y_2+g}{R_1-(y_1+y_2)}$$

$$\therefore x_1 + x_2 = \frac{R+g}{R_1+g}(y_1+y_2+g) \text{ and by (3) } x_2 = \frac{R+g}{R_1+g}y_2$$

$$\text{Hence by (2)} \quad x_2 = x_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Similarly it may be proved that $x_3 = x_1$, and so on. Hence, by equation (4) we see that the wire w is divided into sections,

which have each the resistance $g\,(R + R_1 + 2\,g)\,/\,(R_1 + g)$. When R is equal to R_1 the sections have each the resistance $2\,g$—that is to say, the sum of the resistance of the two gauge wires, and as R_1 is increased the resistance of the sections diminish approaching nearer and nearer to g.

(To be continued.)

SIMPLE ELECTRIC MOTOR.

BY GEO. M. HOPKINS.

It is generally understood that an efficient electric motor cannot be made without the use of machinery and fine tools. It is also believed that the expense of patterns, castings, and materials of various kinds required in the construction of a good electric motor is considerable. The little motor shown in the engravings was devised and constructed with a view to assisting amateurs and beginners in electricity to make a motor which might be driven to advantage by a current derived from a battery, and which would have sufficient power to operate an ordinary foot lathe or any light machinery requiring not over one man power.

1

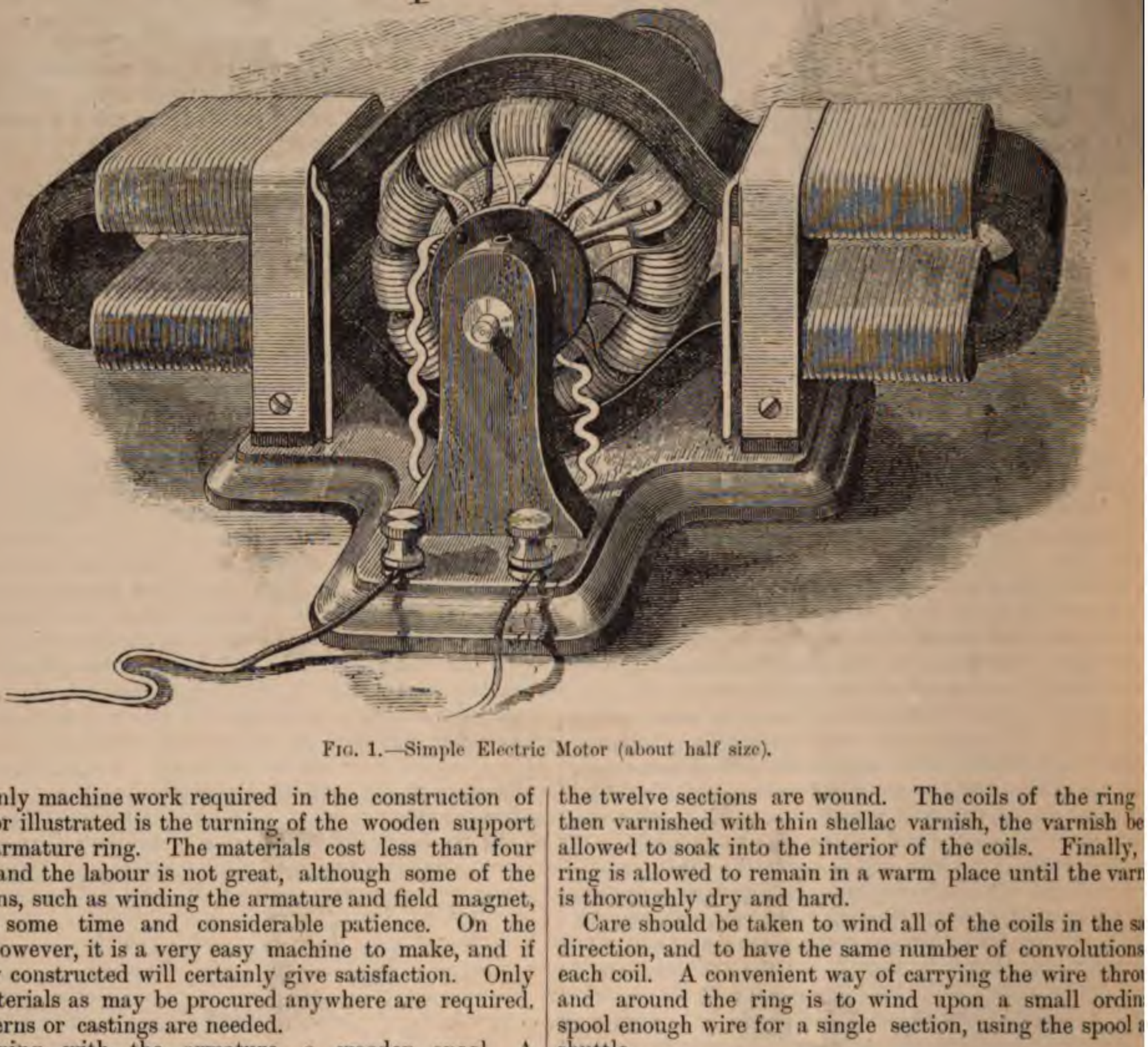


FIG. 1.—Simple Electric Motor (about half size).

The only machine work required in the construction of the motor illustrated is the turning of the wooden support for the armature ring. The materials cost less than four dollars, and the labour is not great, although some of the operations, such as winding the armature and field magnet, require some time and considerable patience. On the whole, however, it is a very easy machine to make, and if carefully constructed will certainly give satisfaction. Only such materials as may be procured anywhere are required. No patterns or castings are needed.

Beginning with the armature, a wooden spool, A (Fig. 2), should be made of sufficient size to receive the soft iron wire of which the core of the armature is formed. The wire, before winding, should be varnished with shellac and allowed to dry, and the surface of the spool on which the wire is wound should be covered with paper to prevent the sticking of the varnish when the wire is heated, as will presently be described. The size of the iron wire is No. 18 American wire gauge. The spool is $2\frac{3}{16}$in. in diameter in the smaller part, and 2in. in length between the flanges. It is divided at the centre and fastened together by screws. Each part is tapered slightly to facilitate its removal from the wire ring. The wire is wound on the spool to a depth of $\frac{3}{8}$in. It should be wound in even layers, and when the winding is com[p]
the spool and its contents should be placed in a hot [
and allowed to remain until the shellac melts and the [
volutions of wire are cemented together. After cooling,
iron wire ring, B, is within from the spool, and cov[
with a single thickness of adhesive tape, to insure in[
tion.

The ring is now spaced off into twelve equal divis[
and lines are drawn around the ring transversely, divi[
it into twelve equal segments, as shown in Fig. 3.
wedge-shaped pieces, C, of hard wood are notched and fi[
to the ring so as to enclose a space in which to wind
coil. This coil consists of No. 16 cotton-covered co[
magnet wire, four layers deep, each layer having eight
volutions. The end, a, and the beginning, b, of the win[
terminate on the same side of the coil. The last laye[
wire should be wound over two or three strands of
thread, which should be tied after the coil is comple[
thus binding the wires together. When the first sectio[
the winding is finished, the wire is cut off and the
(about two inches in length) are twisted together to c[
the coil to retain its shape. After the completion of
first section, one of the pieces, C, is moved to a new posi[
and the second section is proceeded with, and so on u[
the twelve sections are wound. The coils of the ring
then varnished with thin shellac varnish, the varnish be[
allowed to soak into the interior of the coils. Finally,
ring is allowed to remain in a warm place until the varn[
is thoroughly dry and hard.

Care should be taken to wind all of the coils in the sa[
direction, and to have the same number of convolutions
each coil. A convenient way of carrying the wire thro[
and around the ring is to wind upon a small ordin[
spool enough wire for a single section, using the spool a[
shuttle.

The ring is mounted upon a wood support or hub,
and is held in place by the wooden collar, H, both hub a[
collar being provided with a concave flange for receiving
inner edges of the ring. The collar, H, is fastened to
end of the hub, G, by ordinary brass wood screws. B[
hub and collar are mounted on a $\frac{9}{32}$ steel shaft formed
Stubb's wire, which needs no turning. A pulley is form
integrally with the collar, H. The end of the hub,
which is provided with a flange, is prolonged to form
commutator, and the terminals, a b, of the ring coils
arranged along the surface of the hub and inserted in ra[
holes drilled in the hub in pairs. The wires are arran[
so that one hole of each pair receives the outer end of

coil, and the outer hole receives the inner end of the next coil, the extremities of the wire being scraped before insertion in the holes. The distance between the holes of each pair is sufficient to allow a brass wood screw to enter the end of the hub, G, and form an electrical contact with both wires of the pair, as shown in Fig. 4.

There being twelve armature sections and twelve pairs of terminals, there will of course be required a corresponding number of brass screws. These screws are inserted in the end of the hub, G, so as to come exactly even with the end of the hub. This completes the armature and the commutator.

is secured to a base board, G, as shown in Fig. 7, and grooves are made in the edges of the block, and corresponding holes are formed in the base to receive wires for temporarily binding the iron strips together. Opposite each angle of the block, F, mortises are made in the base board, G, to receive the keys, *d*, and wedges, *c*. Each key, *d*, is retained in its mortise by a dovetail as shown in Fig. 8. By this arrangement, each layer of the strip of iron may be held in position as the formation of the magnet proceeds, the several keys, *d*, and wedges, *c*, being removed and replaced in succession as the iron strip is carried around the block, F. When the magnet has reached the required

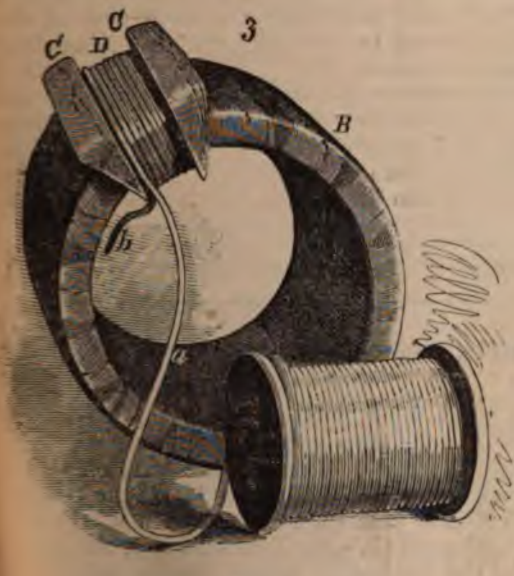
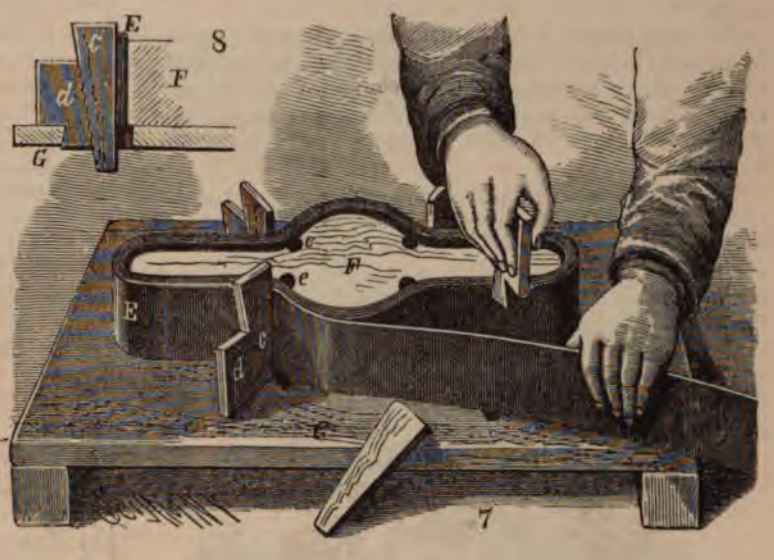
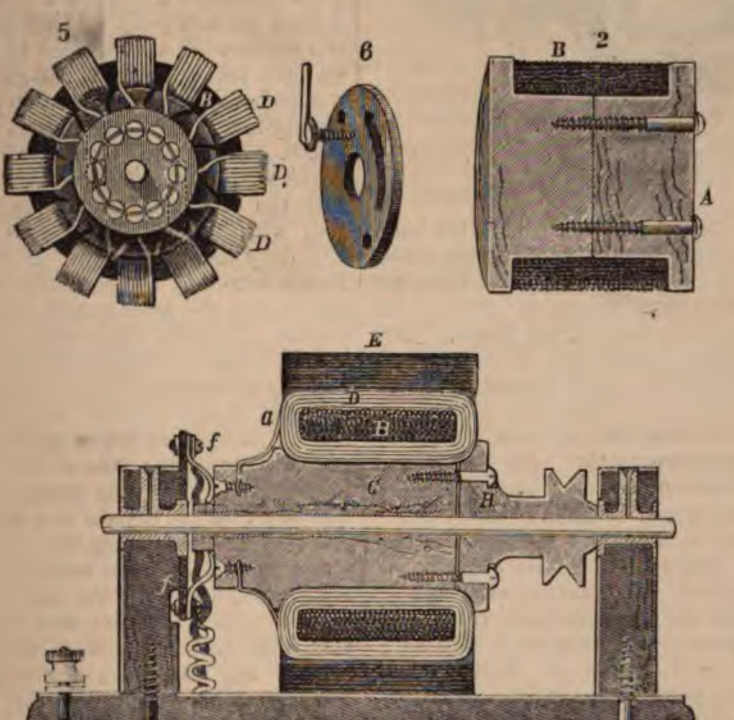


Fig. 3.



Figs. 7 and 8.



Figs. 2, 4, 5, and 6

Before proceeding to mount the armature shaft in journal boxes, it will be necessary to construct the field magnet, as the machine must, to some extent at least, be made by "rule of thumb." The body, E, of the field magnet consists of strips of Russia iron, such as is used in the manufacture of stoves and stove pipe. The strips are $2\frac{1}{2}$in. wide, their combined length being sufficient to build up a magnet core $\frac{7}{16}$in. thick, of the form shown. The motor illustrated has 15 layers of iron in the magnet, each requiring about 26in. of iron; approximately, 33 feet altogether. The wooden block, F, on which the magnet is formed,

thickness, the wedges, *c*, are forced down so as to hold the iron firmly, then the layers of iron are closely bound together by iron binding wire wound around the magnet through the grooves, *e*, and holes in the base board, G.

The next step in the construction of the machine is the winding of the field magnet. To insure the insulation of the magnet wire from the iron core of the magnet, the latter is covered upon the parts to be wound by adhesive tape or by cotton cloth attached by means of shellac varnish.

The direction of winding is clearly shown in Fig. 9. Five

layers of No. 16 magnet wire are wound upon each section of the magnet, the winding of sections 1 and 2 being oppositely arranged with respect to each other. In like manner the winding sections 3 and 4 are oppositely arranged. The winding of section 1 is also opposite to that of 3, and that of 2 is opposite to that of 4. The winding begins at the outer end of the magnet, and ends at the inner end of the section. When the winding is completed, the temporary binding is removed. The outer ends of 1 and 2 are connected together and the outer ends of 3 and 4 are connected. The inner ends of 2 and 4 are connected. The inner end of 3 is to be connected with the commutator brush, *f*. The inner of 1 is to be connected with the binding post, *g'*, and the binding post, *g*, is to be connected with the commutator brush, *f'*.

The field magnet is now placed upon a base having blocks of suitable height to support it in a horizontal position. A block is placed between the coils to prevent the top of the magnet from drawing down upon the armature, and the magnet is secured in place by brass straps, as shown in Fig. 1.

The armature is wrapped with three or four thicknesses of heavy paper, and inserted in the wider part of the field magnet, the paper serving to centre the armature in the magnet. The armature shaft is levelled, and arranged at right angles with the field magnet. The posts in which the armature shaft is journalled are bored transversely larger than the shaft, and a hole is bored from the top downward, so as to communicate with the transverse hole. To prevent the binding of the journal boxes, the exposed ends of armature shaft are covered with a thin wash of pure

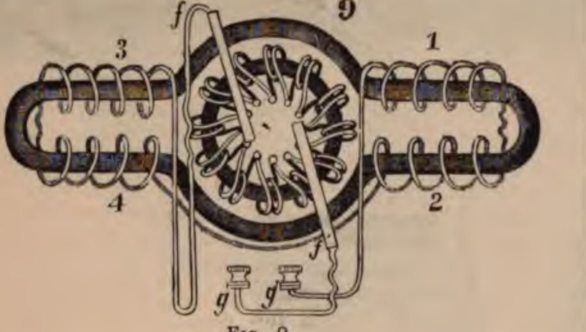


FIG. 9.

clay and allowed to dry. The posts are secured to the base, with the ends of the armature shaft received in the transverse holes. Washers of pasteboard are placed upon the shaft on opposite sides of the posts, to confine the melted metal, which is to form the journal boxes. Babbitt metal, or, in its absence, type metal, is melted and poured into the space around the shaft through the vertical hole in the post. The journal boxes thus formed are each provided with an oil hole, extending from the top of the post downward. If, after cleaning and oiling the boxes, the shaft does not turn freely, the boxes should be reamed or scraped until the desired freedom is secured.

All that is now required to complete the motor is the commutator brushes, *f f*. They each consist of three or four strips of thin hard rolled copper curved as shown in Fig. 4, to cause them to bear upon the screws in the end of the hub, G. The brushes are secured by small bolts to a disc of vulcanised fibre, or vulcanite, at diametrically opposite points, as shown in dotted lines in Fig. 5, and the brushes are arranged in the direction of the rotation of the armature. In the brush-carrying disc is formed a curved slot for receiving a screw, shown in Fig. 6, which passes through the slot into the post, and serves to bind the disc in any position. The disc is mounted on a boss projecting from the inner side of the post concentric with the armature shaft. The brushes are connected up by means of flexible cord, as shown in Figs. 1 and 9. The most favourable position for the brushes may soon be found after applying the current to the motor. The ends of both brushes will lie approximately in the same horizontal plane. When the motor is in operation the direction of the current in the conductor of the field magnet is such as to produce consequent poles above and below the armature.

Eight cells of plunging bichromate battery, each havin one zinc plate 5in. by 7in., and two carbon plates of th same size, will develop sufficient power in the motor to ru an ordinary foot lathe or two or three sewing machines.

The dimensions of the parts of the motor are tabulate below :—

Length of field magnet (inside)	$10\frac{1}{2}$in.
Internal diameter of polar section of magnet	$3\frac{5}{8}$,,
Width of magnet core	$2\frac{1}{2}$,,
No. of layers of wire to each coil of magnet	5
No. of convolutions in each layer	34
Length of wire in each coil (approximate)	95ft.
Size of wire, Am. W.G.	No. 16
Outside diameter of armature	$3\frac{1}{2}$in.
Inside diameter of armature core	$2\frac{3}{16}$,,
Thickness ,, ,, ,,	$\frac{3}{8}$,,
Width ,, ,, ,,	2 ,,
,, ,, ,, ,, wound	$2\frac{1}{2}$,,
No. of coils on armature	12
No. of layers in each coil	4
No. of convolutions in each layer	8
Length of wire in each armarure coil (approximate)	30ft.
Size of wire on armature, Am. W.G.	No. 16
Length of armature shaft	$7\frac{1}{4}$in.
Diameter of armature shaft	$\frac{9}{32}$,,
,, ,, wooden hub	$1\frac{3}{4}$,,
Distance between standards	$5\frac{1}{2}$,,
Total weight of wire in armature and field magnet	6lb.

PUMPING IN MINES BY ELECTRICITY.

We have several times referred to the use of electricity in mines for pumping purposes, and more especially to the very successful work of Messrs. Immisch and Co.; but all previous work has been insignificant beside the pumping plant which Messrs. Immisch and Co. have now laid down at Messrs. Locke and Co.'s, St. John's Colliery, Normanton, of which, by the courtesy of Messrs. Immish and Co., we are able to give the following information :—This new plant is designed to cope with a salt-water feeder of 5,100 gallons per hour, at a vertical depth of nearly 900ft. below the surface. It was decided to raise the water at one lift, and at a rate of about 7,200 gallons per hour, so that the pumps could stand, if necessary, for six hours out of the twenty-four. Since the pressure on the ram faces is about 400lb. per square inch, specially-designed pumps were required, and the electrical plant had to be designed to suit the conditions obtaining. The pumps are differential, with two 6in. and two $4\frac{1}{2}$in. rams. When doing full duty the pumps run at 25 revolutions per minute. It was found, by a preliminary trial of a smaller plant, that the load on the rams varied largely at different parts of the stroke. To avoid the heating that would be entailed in an ordinary motor working under a large current with a regular and rapid variation in its intensity, it was necessary to specially design the field and armature. Messrs. Immisch and Co. have successfully met the difficulty, and the plant has now been raising about 125,000 gallons per day for the last month. To give some idea of the electric problem, we may say that the current averages 66 amperes as read by a Siemens dynamometer; but varies at least 10 amperes on either side of the mean current. Mr. Blakesley has told us, the heating effect of a varying current is not proportional to the square of the mean current, but it is equal to that plus half the square of the variable part. This is not all, however; the rapid variations of current increase largely the heating effects due to hysteresis and foucault currents. The tension on the dynamo terminals is 600 volts, on the motor 575 volts. The actual horse-power in the water, at the rate of 120 gallons per minute through 900 feet, is 33 h.-p. nearly. The output of the dynamo is 53 h.-p. Hence the efficiency between the actual useful work and the output of the dynamo is $\frac{33}{53}$ = about 62 per cent. The commercial efficiency or ratio of useful work to belt power in dynamo cannot yet be stated accurately, owing to slip in the dynamo belt. However, taking the efficiency of conversion of the dynamo at the low estimate of 85 per cent., the commercial efficiency is not less than $\frac{33}{62 \cdot 5}$ = about 50 per cent.

This efficiency includes all the losses in transmission, viz. that in the dynamo, leads, motor, gearing, pumps, and rising main pipes. In this particular case about 2·5 h.-p. is

lost in the cables, and some 13 h.-p. is absorbed by the gearing and pumps, and by friction of the water in the pipes. It is contemplated shortly making a more complete test. Then indicator diagrams will be taken of the engines and pumps, and the various losses will be determined very exactly. But returning to our 50 per cent. conversion between the measured quantity of water and the brake engine power, could compressed air give such a return? The supporters of electricity would with much reason believe that compressed air would not give a return of more than 20 per cent. of the brake engine power. At any rate, it is curious that not one of the advocates of pneumatic transmission will publish a test of his plant. Mining engineers who have carefully measured the water delivered, and indicated their engines, give the result as varying from 15 per cent. to 25 per cent., and this latter under most favourable circumstances, Several gentlemen have recently written in the columns of the technical press advocating compressed air, and doubting the practicability of electricity. Surely now is their time to vindicate their position by figures and hard facts. In comparing the two systems, one must bear in mind that the losses in the steam engine, pumps and raising main are common, and can therefore be neglected as having no vital bearing on the real question. What we have to compare is the loss in dynamo, cables and motor, and that in compressors, supply pipes, accumulators, and air engines. The loss in the cable and supply pipes may also be struck out as quantities varying in every case, they affect more the capital outlay. Now a good dynamo and motor have a joint conversion efficiency of not less than 75 per cent., and under favourable circumstances may rise as high as 82 per cent. or even 84 per cent. But what will the most sanguine say about the compressors and air engines? Will they claim 50 per cent. and give the figures, as electrical engineers do? Probably, under very favourable circumstances, with low pressures, 50 per cent. might be reached, but with high pressure (such as would be required for 7,000 gallons per hour through 900ft., without an extravagantly large plant), the efficiency would be probably not more than 25 per cent.

Another important point of comparison lies in the prime cost of the plant. Omitting again the factors common to both systems, we have first a leading and return cable to set off against the pressure pipes. In most cases, the cables will cost both less than the pipes, and will be cheaper to erect. A double cable to transmit 50 h.-p. was run by Messrs. Immisch and Co. down a shaft of 300 yards deep in 7 hours. The dynamo and motor will be found also to cost less than the compressors, accumulators, and air engine to do the same work.

The question of prime cost is an important one; but, perhaps that of maintenance and security of running is more important still, in cases where breakdowns may entail very serious consequences. With electricity the cost of maintenance, judging from a large and varied experience of its application to nearly all kinds of machinery, is practically limited to the wear of brushes, commutators, and bearings.

A well made commutator also gives little or no trouble, and if kept clean will last a considerable time. The bearings will last for a long time, owing to the even strain put upon them. Of course, electrical plant requires to be properly designed for its work, and to be well laid down. But the majority of accidents that are likely to happen to such plant can be readily and quickly repaired and compare very favourably with the ugly breakdowns that occur with machines containing reciprocating parts. Indeed, if a proper method of management and daily testing of the system be made, a really serious breakdown is a very unlikely thing, for a fault is easily detected and made good before damage is done. No one, who has had experience of the two systems, will fail to endorse this. With compressed air plant there is not so much a risk of a bad breakdown, as a continual fettling up of the brasses, crank pins, cotters, valves, valve seats, glands, &c., The number of wearing parts is so numerous and the strains so various that it is not to be wondered that the cost of maintenance is comparatively heavy.

It may be mentioned that the motor weighs about 3½ tons, and the dynamo nearly 4 tons. The machines are much heavier than the ordinary Immisch type for traction purposes, in which every 70lb. of dead weight gives approximately a brake horse-power. But here weight did not enter into the question so much as slow speed and cool running. The machines are working well within the limits of their design, and are capable of doing 50 per cent. more work if necessary. The armatures, 24in. in diameter and 16in. long, are of the cylinder type, with massive commutators and substantial brushes and holders. The motor is wound according to Immisch's patent, and to this is mainly attributed the fact that they run practically sparkless, with a constant lead, although the load is varying 30 per cent. during every revolution of the pump. The speed of both dynamo and motor is 450 revolutions per minute.

The engine is a compound semi-fixed by Messrs. Robey & Co., of Lincoln, and works at a boiler pressure of 140 pounds per square inch. It is a 30 h.-p. nominal. The engine is similar to the one illustrated in our issue of March 2, but the smaller illustration (for which we are indebted to Messrs. Robey & Co.) given below will show the type of engine to those who may not have seen the number referred to.

Further particulars will be given when the full test is published. That the plant is a success may be judged from the fact that Messrs. Locke and Co. have given an order for two new machines of the same power. This new plant will be used to work an endless rope on an engine plane by day; and will be ready for pumping at night if required. This electrical plant is by far the largest at present running at a coal mine. It is confidently expected, however, that it will not long remain singular in this respect.

Insulating Cement.—According to the *Moniteur Industriel*, the Director of the Vesuvius observatory possesses an electrometer which is supposed to be the most perfect instrument of its kind. It was in reference to this instrument that M. Mascart observed, at the Meteorological Congress held in Rome—"So perfect is it that it might serve to control the indications of all other instruments of the same class in the world." This superiority is said to be due to the material with which the insulation is effected, viz., a cement formed of pitch from Greece (*poix grecque*), two parts; and calcined plaster, one part. The plaster in question, termed in Italian *scagliola*, is pure gypsum, which has been raised to a high temperature and thus deprived of half its water of constitution. It is a superior kind of plaster of paris, and, when mixed with water, hardens after combining with the proportion of this fluid which had been expelled by heat. The cement formed by admixture of the pitch with this plaster (presumably in the semi-dehydrated condition) is, when hot, a homogeneous viscid paste; it may be applied to apparatus by means of a brush, or it may be cast in moulds of any required form. It possesses the insulating properties of ebonite; but is softer and more plastic. A skilful manipulator can turn and polish it in the lathe. In colour it is slightly darker than amber. From the electrical point of view, its characteristic and useful property is that it retains its insulating power, whether it be exposed to a high temperature or to a moist atmosphere. We may add to the above that, at the period when Peltier's or Milner's electrometer was in common use for testing the insulation of cables, we obtained the most perfect insulation with a cement composed of shellac, gum dammar, and paraffin wax.

THE

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

AN EXPERIMENT.

The experiment of Mr. Bennett, the surveyor of Southampton, is one that should be kept well in view, for not only has it an influence upon the spread of electric lighting, but it makes electric energy, so to speak, a bye product. It may be well to recapitulate the experiment. A portion of the town refuse at Southampton is rendered innocuous by means of a destructor, which may be said to be a kiln especially designed for this purpose. Just as for many years the heat of smelting furnaces was wasted, so hitherto the heat generated by the destruction of refuse in these kilns has been lost. The idea suggested itself to Mr. Bennett of utilising the waste heat in generating steam, and the steam thus generated he used in driving a dynamo and producing the electric light. The general public, misled by the discussions upon the cost of the electric light, and usually not taking into account the whole data on the subject, hold strongly to the opinion that if they can only get natural power—wind or water—to drive the dynamos, the cost of the resultant light must be cheaper than the cost of gas. Of course all electrical engineers know that this result does not necessarily follow, nor must we be led into rash promises because we see the way to get the heat to generate the steam for nothing. While, however, we retain the right to examine every case upon its merits, generally speaking the utilisation of such waste heat will enable the electric light contractor to produce a result that should end in a large accession of business.

The possibilities arising out of this successful experiment are far beyond anything that can be understood by the ordinary electrical engineer whose business has led him very little among local authorities. Speaking with an experience which has brought us more or less into contact with every local authority in the United Kingdom, we can say unreservedly that one of the most difficult problems surveyors and engineers have attempted to solve, is that of getting rid of "town refuse." During the past few years great attention has been paid to the results obtained by these "destructors," and if they can be made to "kill two birds with one stone," we are convinced they will soon be reckoned by hundreds rather than as now by units. At present the destruction of the "refuse" is altogether a loss, which has to be borne by the rates; or, if that statement is going too far, we will say the return is so inappreciable that it is not taken into account. Mr. Bennett has shown a method by which a large part at least of the loss can be obviated. The construction of the "destructors" might with advantage be considerably altered, if they were erected with the double object of destroying the refuse and providing heat for the boilers.

The whole subject is of interest to the electrical engineer; but it is of far greater interest to the

borough engineer or surveyor. The first duty of the latter is to get rid of the refuse as cheaply as possible, and if he has decided that a destructor is the proper way to do this, he will most certainly get as large a return as he can for his expenditure. The figures attending such an experiment as that of Mr. Bennett must be taken as higher than would be the case in a properly designed installation. Probably, to drive one dynamo, only a fractional portion of the heat of the destructor is used. In an installation designed specially with a view to utilise this heat, the whole and not merely a part would be used. Small towns might, when the destructor could be conveniently placed, arrange for the whole of the lighting of the streets, if not for the lighting of the houses.

Unlike the case of an ordinary installation, where the cost of coal has to be carefully considered, the initial expense is the principal item under the conditions referred to. This opens up another vista to the local authorities as well as to the electrical engineer. The former will perhaps be ready to enter into a contract with the latter to supply a required number of heat units at so moderate a rate that the latter can safely enter into competition with rival illuminators. Suppose, for example, we take a destructor capable of giving heat to generate 1,000 h.-p., how would the obtaining of this heat at a moderate cost affect the maintenance of an installation of ten thousand lamps?

The coal consumed for such an installation would alone cost at, say, from 15s. to 20s. a ton, from £2,500 to £3,500 a year. The labour cost of putting this coal from the yard into the furnace would increase this item, and so far, if the proprietors of the destructor were using the heat themselves, the whole of this would be saved. On the other hand a purchaser in these early days of the suggestion, would probably get the "heat" at a very moderate cost. As time goes on and competition gets keener, the contractor would have to pay more. Further, many local authorities would be glad to pay a lump sum to a contractor to take the "destructor" work into his own hands, letting him do the best for himself that he could, so far as utilising the heat was concerned.

We have only glanced at this question, because just as one swallow does not make a summer, one experiment does not make a success. Further experiments will undoubtedly be made, when more can be said on the subject? Meanwhile we are strongly of the opinion that there is "money" in the idea, and that those firms whose tendencies are in the direction of town lighting, will do well to enquire closely as to the capability for using the heat of these destructors, and also where they are in existence or likely to be erected. The latter case presents the best opportunity for business.

CATALOGUE PIRACY.

A letter in another column directs attention to a practice that is becoming much too common. It is easy, as our correspondent says, to make up a respectable catalogue by taking information indiscriminately from various sources without acknowledgment. It is probable that the information so taken has been obtained at considerable expense in the original, and the pirate escapes all this trouble and expense. It is difficult, if not impossible, to prevent one firm following the arrangement of another firm; but even this has frequently been obtained at considerable cost, the first drafts having been altered and corrected till the appearance meets the approval of the principal. The Society of Telegraph-Engineers is, we fear, hardly the authority to adjudicate upon what, after all, are almost entirely trade questions; and, therefore, it does seem probable that sooner or later some other organisation must be provided to veto such practices. Our contemporary, *Electrical Plant*, suggests that a branch of the London Chamber of Commerce should take up questions affecting the welfare of the industry; but, again, it is doubtful whether the result would be that hoped for. The millenium is long in coming, and till then there will be business men who, in order to obtain some of the crumbs that fall to the share of well organised, successful firms, will follow as closely as possible the lines pursued by the successful ones. Sometimes the method of procedure leads to the law courts, but generally the pirating firm gets off scot free. The ordinary customer unfortunately knows nothing of how a catalogue is compiled, and believes when he receives one that it is the outcome of the purse and the brains of the firm which forwards it to him, and there is no means of dispelling this idea.

PITTSBURGH CONVENTION.

For the past week or two we have devoted a large amount of our space in reporting the various papers read at the recent American Conference of Electric Light Engineers at Pittsburgh. We have done this because, as might indeed have been expected, similar topics interest English electrical engineers, which also interest our brothers across the Atlantic; thus we have endeavoured to give a fair idea of the papers read as quickly as possible after the meeting. It will be seen from the reading of these papers that they almost wholly consist of the discussion of questions directly connected with practical work, and to a very little extent do they deal with anything purely theoretical.

CORRESPONDENCE.

FIRE OFFICE RULES.

To the Editor of the Electrical Engineer.

Sir: We, in common with the author of the letter on the above subject in your last issue, feel exceedingly

alarmed at the prospect that opens out before us now that another set of rules have been published.

It would be difficult to arrange, at the present stage of the industry, any set of rules the following out of which could better guard against dangers arising from electric lighting than those which have been drawn up by Mr. Musgrave Heaphey.

The writer has seen a number of installations, both on the Continent and in the United States, with the result of feeling assured that work of this kind in England is infinitely superior to that carried out in other countries, and there can be no doubt that our comparative immunity from fire arises from the judicious enforcement of these.

A number of installations in this kingdom, including one or two of the largest, have been carried out by us, always under the Phœnix Fire Office Rules, and in no single instance has an electrical fire occurred.

It must certainly be the experience of every contractor that there is no difficulty in obtaining the approbation of the authorities for installations conscientiously executed.

If we are to have several sets of rules, it will be impossible to tender for work without a specification, and this means an expensive item added to the price of electrical work for the services of a consulting electrical engineer in each case, whose presence is unnecessary when a duly qualified fire inspector fills the position, free of cost, to the proposed user of the electric light.

We do think that this is a matter for the leading contracting firms to interest themselves in, and their verdict goes almost without saying.

To frame and impose rules, it is necessary to have a "status"—what is the "status" of those who are seeking to introduce the new ones, and what authority have they to handle a matter which so seriously affects the trade without first consulting it ?

The matter is such a serious one that we trust more *direct and public impeachment* will quickly ensue.—Yours, &c.,

London, March 22, 1888. INSTALLERS.

CATALOGUE PIRACY.

To the Editor of The Electrical Engineer.

Sir : As a further contribution to what has already been written on this subject, we would point out that the "catalogue of cables, leads, and insulated wires," issued this month by the Telegraph Manufacturing Company (Limited), of Helsby, contains exact copies of our price-lists of April, 1887, the only variation being different pattern numbers, and the omission of our name. Those interested in the subject might compare pages 10, 11, 12, 13, 14, and 15, with our April (1887) price-lists. Not only are our figures copied *exactly*, but our phraseology, simply *seriatim et litteratim*. Probably other parts of the catalogue have been made up by equally flagrant copies from other makers' lists, if we may judge from pages 30 and 31, where Cheeseman's table and formula are given without acknowledgment.

Surely our Society of Telegraph-Engineers and Electricians might extend its sphere of usefulness by adjudicating on questions of privilege, and consider whether persons guilty of questionable practices are entitled to remain on their roll of members.—Yours, &c.,

WALTER T. GLOVER AND CO.

Salford Electric Wirework, Manchester,
March 26th, 1888.

THE EQUITABLE TELEPHONE ASSOCIATION LIMITED.

[We have been requested to print the following notice.—Ed. *E. E.*]

The United Telephone Company having commenced proceedings for infringement, which they are advertising in the public press, against the Equitable Telephone Company, and having obtained against the latter Association an interim injunction, which they are also advertising, pending the trial of the action, which trial cannot come on for some months, the Equitable Telephone Association think it right to justify the conduct of their past business.

The Association was incorporated as long ago as the 15th December, 1886, and although advised by eminent counci that the instruments intended to be used by the Associatio were not infringements of the patents held by the Unite Telephone Company, yet the directors of the Associatio thought it right, having been informed of the pretension of the United Telephone Company to a monopoly of th telephone business of the country, before commencing t supply instruments, to challenge the United Company t attack such instruments, with the hope and intention tha the challenge would be accepted, and the litigation, whic was then considered inevitable, terminated before the Asso ciation commenced to supply telephones to the public.

With this view the following letter was addressed by th solicitors of the Association in February, 1887, to th United Company, giving express notice of the intention t manufacture and sell telephonic apparatus under M Swinton's patent, and challenging the United Company t attack, if they dared do so, the instruments proposed to b manufactured and sold :—

"40 and 42, Queen Victoria-street, E.C.,
"February 25, 1887.

"Dear Sir,—We are instructed by the Equitable Tele phone Association, Limited, to inform you that th Association is about to manufacture and sell telephoni apparatus, the transmitter of which is constructed unde the various patents of Mr. A. A. Campbell Swinton, whos patent rights the Company has purchased.

"In order to give you an opportunity of inspecting th instruments, a set has been fitted up at these offices, an we are prepared to arrange an appointment to produc them for the inspection of yourself and your Company electricians.

"We should add that the Company is advised by eminen counsel that the instruments are in no way infringement of the patents held by your Company, but knowing the ex tent of the claims made by your Company, ill founded claims we believe, to altogether prevent the use of any electric transmitters in which carbon is used, the board of directors of our Company think it right to give your Company distinct notice of the intentions of the Association with the view to challenging your Company to contest the right of our Company to manufacture, use, and sell the instruments in question, should your Company after inspection think fit so to do, a contest which our directors will enter into with the full assurance they will succeed in maintaining the instruments it is the object of the Association to deal with."

"Yours faithfully,
"DAVIDSON & MORRIS."

To this challenge the United Company did not respond, and until the 9th of the present month of March, when a writ was issued without any previous warning or notice by the United Company against the Association, no objection was made by the United Company to the business the Association was transacting. This writ was followed by a motion for injunction, which was heard on Friday, the 16th March, when an interim injunction was granted, restraining the Association in the usual terms from dealing with telephonic instruments, the United Company giving the usual undertaking to be answerable in damages caused to the Association.

Owing to the short time at their disposal the Association was practically precluded from producing any scientific evidence on the hearing of the above motion, and their defence therefore rested solely on the question of there having been undue delay on the part of the United Company.

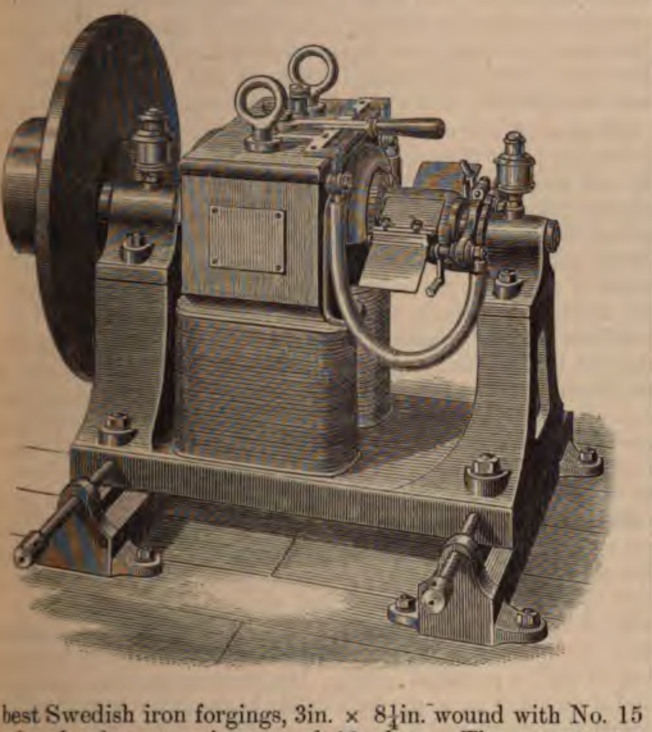
The Association have every intention of contesting the action to the utmost of their ability, and they will press the the case on as far as lies in their power, with a view to as early a trial as practicable.

They believe that they have a complete defence, and they have every confidence that they will be able to uphold the complete freedom of their instruments.

THE FOWLER-LANCASTER DYNAMO.

It will be recollected that a few weeks ago we describe a private installation at the house of Mr. Fowler (of Messr Fowler, Lancaster and Co.), and mentioned that the dynam used was one built by that firm, driven by a Speil

petroleum engine. We herewith illustrate the dynamo which, as will be seen, is of the Kapp type, with armature gramme ring, having a core built up of best Swedish charcoal-iron discs of No. 22 B.W.G., insulated from each other with double tissue paper. It is wound with 48 sections of four turns single layer of No. 11 B.W.G. wire, and has a resistance of ·06 ohms. The field-magnet cores are of the



best Swedish iron forgings, 3in. × 8¼in. wound with No. 15 wire, having a resistance of 18 ohms. The output at a thousand revolutions is 53 amperes, with a pressure of 62·9 volts. It will be seen from our illustration and from these few details, that the machine is constructed according to the most modern practice, and it has in this special installation a heavy fly-wheel in order to obtain as regular running as possible.

WHAT CONSTITUTES A GOOD CARBON POINT.*

BY G. W. PARKER.

From the standpoint of the manufacturer all well-baked carbons that are straight, free from cracks and other similar defects, and made from pure material, are good carbons.

The electric light engineer will say that no carbon is good unless it will centre properly and give him a reasonably long life with a good light. He is not at all inquisitive as to the method of its manufacture, provided it gives such results.

But as the manufacturer can go no further than to correct any error in his mechanical processes, the value of the carbon afterwards depends upon the conditions of its use. Such carbons as are described in the first paragraph will with some currents be satisfactory, both as to light and life. In others, the light may be brilliant and the life too short, or there may be arcs too short or too long, flaming or other defects arising from the unsuitability of the carbon to the current, there being no inherent defect in the pencil itself. Therefore, to cover the whole ground of this important inquiry, we should also have the carefully compiled statements of your experience of the behavior of carbons burning in your lamps under varying circumstances. From this results of great value to both sides might be obtained.

There appears to be no trouble in determining what constitutes a good carbon mechanically, but to you a good carbon means one that will give you satisfactory results in your use of it, and there we find several difficulties, without taking into account imperfections in your apparatus. The first is the difference in the strength of the currents used in the different systems, and also, in many cases, in different plants of the same system, the corresponding differences in the resistence of each lamp, and, frequently, unequal adjustments of lamps in the same plant.

For convenience we are in the habit of referring to those systems in which a small current and a long arc is used as high tension systems, and those in which a large current and a short arc is used, as low tension systems. The requirements of the low tension seems to be a carbon that is hard, well plated, and a good conductor, the latter being the most important. In the high tension, on the contrary, hardness and conductivity seem to be of secondary importance. There is a tendency to flame and burn unsteadily when a hard carbon is used in these systems, and a softer one sometimes becomes necessary, which in many cases shortens the time in which the lamp will burn without being re-trimmed, but in such cases the difference is fully made up in the brilliancy of the light. On the other hand, where a soft carbon is burned in a low tension current, the tendency is to form needle points which prevent the carbon from centring properly, causes them to heat and is apt to burn the holder.

Let us pursue the inquiry touching the questions of size, conductivity, mortality and light, and ascertain if definite relations can be established in regard to them that may result in guiding us in the selection of perfect carbons for use from a mass of mechanically good carbons.

Diameters.—It is a matter of great interest to know in what manner and to what extent the size of the carbon affects the result in a current of given strength, covering, of course, in the general question of conductivity, the all-important results of light and life.

Hardness or Conductivity.—It is well known that a hard carbon offers less resistance to the current, or, in other words, has greater conductivity than a soft one; therefore, in carbons of the same length and diameter, made of the same material, by the same process, conductivity increases and diminishes respectively with their hardness and softness. In either hard or soft carbons, whatever conductivity they possess respectively will be increased or diminished as their diameters are diminished, the length being maintained. It would appear, therefore, that it is possible to make a softer carbon of larger diameter that will be the equivalent, in conductivity, of a harder carbon of smaller diameter.

Mortality of Carbons.—Of carbons of the same hardness and length, but having different diameters, the larger will undoubtedly outlive the smaller. Of carbons of the same diameter and length, but differing in hardness, the harder will outlive the softer. Therefore, a carbon of larger diameter, which is soft, may be equivalent to a smaller carbon which is hard, as to life, just as it has been shown to be equivalent in conductivity. The life of a carbon is, of course, dependent upon many vicissitudes, such as high winds, broken globes, &c., but under the same conditions the statement made above is undoubtedly a fact.

Brilliancy of Light.—It is well known and admitted that as between hard and soft carbons of the same diameter the latter will give a more brilliant light. It is just as well known that in case of hard carbons those of smaller diameter will, within certain limits, give a more brilliant light than those of a larger diameter. On the above statement of facts it may be regarded as settled then that with the same diameter, but differing in hardness, the hard carbon will possess greater conductivity and have a longer life, but with less brilliancy of light; while the softer carbon will have less conductivity and a shorter life, with a more brilliant light. And, further, that with uniform hardness, but differing in diameter, the larger diameter will have the greater conductivity and longer life, with a less brilliant light; while the smaller diameter will have less conductivity and a shorter life, with a more brilliant light.

The foregoing statements indicate invariably that with greater conductivity light diminishes and life increases; and, conversely, that with diminished conductivity the brilliancy of the light is increased and the life shortened. In corroboration of this it appears that a small hard carbon is, practically, the equivalent of a larger, soft carbon, their conductivity being also equivalent.

Heretofore it has been considered probable that the diameter, candle-power, resistance per lamp, conductivity of the carbon point, and strength of current are all inter-

* Paper read before the National Electric Light Convention at Pittsburgh.

dependent, and a change in any of them will affect all the others, requiring a counteracting change or adjustment in some of them, in order to restore the proper relations between them. This, if so, you can readily see is difficult to do, for part of the work is to be done by the manufacturer, and the remainder is under your control.

On the other hand, if the deduction can be properly made from the statements herein presented, that the resistance of the carbon point will determine its capability in respect to light and life in the different currents, the trouble is practically removed. It is not impossible, I think, to construct a machine that will, at no great increase of cost, assort the carbons into groups of uniform resistance or conductivity. Then, with constant currents, clean lamps, perfect connections and insulation, you will ascertain practically that carbons mechanically good will prove to be good, and uniformly so, in actual service.

Much more could be written upon this interesting question, but this paper is already too long. I have noted for your discussion some important points which I hope your experience will enable you to determine definitely if they are well taken or not. I would be glad to have the whole question of the imperfect burning of carbon points thoroughly canvassed, so that manufacturers would get some hints as to what may be done by them in the way of correction when the fault lies at their door. It is especially desirable to be informed if that very disagreeable feature in the burning of carbons called "flaming" is always the effect of one particular cause and what that cause is.

THE UNDERGROUNDING OF ELECTRIC ARC WIRES.*

BY W. W. LEGGETT.

This topic is one of absorbing interest at the present time. Municipal and legislative authority seeks to compel the burying of all the wires without discrimination, and to cast upon the parties interested the burden of finding a practical means to accomplish the end. The progress of invention in science and art records, infallibly, the contemporaneous public drama. This demand discloses a necessity, and inventive ingenuity suggests the remedy.

Starting from this standpoint we find public wiring began with the telegraph. In 1753 Marshall, of Paisley, evolved an electric telegraph wherein insulated wires were to be trained on poles, and so Lomond in 1787, Beton Court in the same year, Riezen in 1794, Cavallo in 1795, Salva in 1796, Sœmmering in 1809, Coxe in 1810, and Sharp in 1813 all had telegraphs employed, from one to twenty-six wires, trained on poles.

At this stage, however, the interesting experiment to which the world lent a helping hand developed signs of commercial utility and value. Man's cupidity and selfishness at once antagonises what he cannot share, and we find the public arrayed in opposition to the use of the highways. Inventive ingenuity came to the rescue, and in 1816 Ronalds erected and used a telegraph in which some of his wires were placed on poles, and *some were buried in the ground*. Tribavillet followed, in 1828, with a system employing underground wires; and when Prof. Morse, in 1832, brought out his system, he proposed connecting Washington with Baltimore, a distance of 44 miles. To his mind, the wires should be insulated in a tube laid in the ground. He constructed his line with great care, and at large expense; but only a few miles had been laid when the gradual escape from his line proved his scheme impracticable. He was about to abandon the undertaking, when one of his coadjutors, Dr. Page, of the Patent Office, or Prof. Henry, of the Smithsonian Institute, said to him: "Take your wire from the ground, and train it on poles." The advice was followed and success achieved. Here, then, in the incipiency of public wiring is the first recorded failure coupled with its remedy. Take the wires from the ground and put them on poles. With underground telegraph and telephone wires the electrical difficulties to overcome are much the same. Moisture must be excluded from the wires, insulation must be good and induction be reduced to the minimum, especially between adjacent lines. In both, however, leakage from the lines due to imperfect insulation may be compensated within limits by additional battery force. The battery acts like a pump sending water through a leaky pipe; the water may all escape before reaching the discharge end, but with a more powerful pump, while increase of pressure will cause greater escape through leakage, one may succeed in discharging a limited quantity through the end of the pipe, and so accomplish the purpose sought. For this reason underground telegraph and telephone wires may be operated with a measure of success.

In most of our cities all telegraph wires might be led to a certain point from which the wires of all systems could by one underground conduit be led to a central station or stations, and thence back through the same conduit, and where the wires are numerous might warrant the expense. With telephone companies whose subscribers are in all parts of the city, the requirements that each wire should be conveyed underground would involve an outlay for conduits wholly prohibitive. For direct service incandescent lighting the required conductors are so large, that to train them upon poles, or to train an equivalent capacity in smaller wires on poles, would involve outlay and annoyance exceeding that required to underground the conductors. So, again, the resistance of the conductors to the flow of the current is exceedingly slight; it might be compared to the pouring of water from a pitcher through a six-inch pipe, its course of least resistance lies right forward through the pipe and there is little tendency to seek an exit through any other restricted channel. In comparison with it the arc light current might be likened to a large hose with a small nozzle, through which water is being forced with a powerful pump; the tension is very great, and if so much as a pin hole exists in the hose water will squirt therefrom and quickly enlarge the orifice to a fatal rent. From the fact, therefore, that telegraph and telephone and incandescent electric light wires may be trained underground with success, by no means does it follow that the same is true of arc light wires. It is an undoubted fact that to successfully underground electric arc light wires involves simply and solely a question of expense. But expense may be of the very essence of the inquiry, for if the expense is out of proportion to the revenue that can be derived from the service, expense alone prohibits the outlay and determines it to be impracticable. Expenditure of money is alone required to tunnel the Dover Straits, and yet French and English capitalists have pronounced it wholly impracticable, as the returns could not warrant the investment. So it is with electric arc light wires; an efficient system so far as inventive ingenuity has yet presented any plan involves an expenditure wholly prohibitive, and for that reason alone is impracticable. Electric arc light wires may be employed successfully, trained in the air on poles, and an underground system is practicable which can reproduce the same conditions. Let us examine these conditions. All substances are conductors, as copper, iron, lead, rubber, glass, dry air. Some substances are such poor conductors, that, in comparison with those that are better, we call them non-conductors, and the greatest availabe non-conductor is dry air. We use these poor or non-conductors, such as rubber, glass, paraffin, wood, and dry air as insulators, and we find dry air to be our most perfect insulator. Dry air is a better insulator than rubber; if, therefore, in dry air two rubber covered wires cross in close proximity to each other, the induction is greater between them than would be the case if both wires were bare. But air is usually laden with moisture, and water charged as it is with the mineral salts and acids of the atmosphere, is a good conductor. We therefore coat our line wires with an insulating material, to shield them from direct contact with moist surfaces or other good conductors, and so reduce in amount the current which is always escaping by connection to the ground, and which varies in direct proportion to the conducting property of the intermediate medium. Where insulated wires are trained on poles, we have, at the rate of 30 poles to the mile, thirty points at which a small amount of current may and always does slip off to the ground. Now let us put an insulated cable in a con-

* Paper read before the National Electric Light Convention at Pittsburgh.

Table I. shows the maximum loss expressed in volts, the corresponding maximum per cent. of loss, the corresponding average per cent. of loss, and, consequently, the average efficiency of the system of conductors :—

TABLE I.

System.	Three wire System.			1,000 Volt Alternating Current System.		
Maximum loss in volts ...	12·5	20	30	25	50	100
Maximum loss in per cent.	10	15	20	2·5	5	10
Average loss in per cent...	4	6	8	1	2	4
Average efficiency	96	94	92	99	98	96

These two tables show the individual efficiency of the different portions of the two systems, and the total efficiency from the driving belt up to and including the portions named. I have granted in all cases for the converter system an efficiency of 98 per cent. for the primary and 99 per cent. for the secondary conductors. With a commercial efficiency of 90 per cent. for the generator and 95 per cent. for the converter, which is sometimes claimed for them by some, the total efficiency is 82·9 per cent. With a commercial efficiency of 85 per cent. for the generator and 90 per cent. for the converter, which is believed by others to be liberal, the total efficiency is 74·2 per cent. In the three-wire system we have assumed an efficiency of the generator of 92 per cent., which result is obtained by every maker of a first-class dynamo of this type ; and an efficiency of 99 per cent. for both the mains and the inside wiring, both of which portions of the system are in practice calculated for a maximum loss of 2 per cent.

The maximum loss in the feeders in Table II. is made 10, 15, and 20 per cent., with a corresponding average loss of 4, 6, and 8 per cent., and an efficiency of 96, 94, and 92 per cent.

TABLE II.—*Alternating Current Converter System.*

—	Indiv.	Total.	Indiv.	Total.	Indiv.	Total.
Efficiency of generator......	90	90	88	88	85	85
Efficiency of feeder	98	88·2	98	87·2	98	83·3
Efficiency of converter......	95	83·8	92	79 3	90	75
Efficiency of services and inside wiring...............	99	82·9	99	79·5	99	74·2

Three-Wire System.

—	Indiv.	Total.	Indiv.	Total.	Indiv.	Total.
Efficiency of generator ...	92	92	92	92	92	92
Efficiency of feeder	96	88·2	94	86·5	92	84·6
Efficiency of mains	99	87·3	99	85·6	99	83·7
Efficiency of services and inside wiring	99	86·5	99	84·7	99	82·9

Assuming the highest efficiency claimed for the alternating current generator; and assuming the generator is as efficient as a continuous current generator under conditions of partial load, which is not likely ; and assuming that the converter has the same efficiency under partial load as under full load, which we know cannot be ; we are still met with the fact that the three-wire system, with a maximum loss of 20 per cent. in the feeders, has as high an efficiency as the converter system, allowing it every possible claim ; and that the three-wire system, as usually installed, with a maximum of 10 per cent. loss in feeders, has a superior efficiency of from 4 to 12 per cent. over the alternating current converter system.

To return now to the question of first cost, assuming the cost of copper at 16 cents per lb., I have figured the cost of copper conductors for feeders for 16 c.-p. ; 50 watt lamps, for distances of 1,000, 2,000, 3,000, 4,000, 5,000, and 6,000 feet, with an average loss in conductors of 4, 6, and 8 per cent. for the three-wire system, and 2 per cent. for the alternating system, with 1,000 volts initial E.M.F. ; cost is expressed in dollars and decimal fractions thereof.

I have also calculated the cost of copper in the mains for one 16 c.-p. lamp on the basis of a distance of 800ft. between feeder terminals in the three-wire system, and a maximum loss of 2 per cent., and find it to be 13 cents. Also the cost of services and inside wiring, in the three-wire system, on basis of an average distance to lamps of 100ft., and 2 per cent. loss ; and since the full benefit of the three-wire distribution cannot be attained in the inside wiring, have assumed the saving of one-third over the two wire system, instead of the two-thirds saving effected in cases where the full benefit can be attained. On this basis, the cost of copper for services and inside wiring is 6½ cents per lamp.

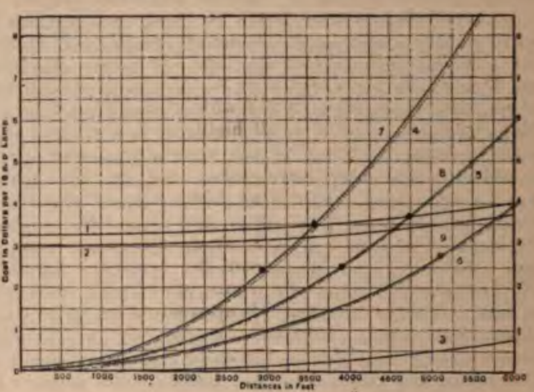
TABLE III.—*Cost of Copper for Three-Wire Feeder per 16 c.-p. lamp (50 watts, 110 volts). Copper at 16 cents per lb.*

Distances...............	1,000	2,000	3,000	4,000	5,000	6,000
12·5 volts maximum loss equals 5 volts average loss, which is 4 per cent.	·266	1·064	2·394	4·256	6·65	9·576
20 volts maximum loss equals 8 volts average, which is 6 per cent.	·1615	·646	1·453	2·584	4·037	5·812
30 volts maximum loss equals 12 volts average, which is 8 per cent.	·1077	·430	·969	1·723	2·69	3·87

Cost of Primary and Secondary Circuits and Converters for 1,000 Volt Alternating Currrent Converter System, per 16 c.-p. lamp at varying distances.

Distances	1,000	2,000	3,000	4,000	5,000	6,000
Primary................	·0213	·085	·191	·340	·530	·764
Converter	3·000	3·000	3·000	3·000	3·000	3·000
Secondary	·240	·240	·240	·240	·240	·240
Total	3·2613	3·325	3·431	3·580	3·770	4·004

In the alternating current converter system I have assumed the cost of converters recently quoted by Mr. Stanley, the electrician of the Westinghouse Company, in a paper before the Boston Society of Arts. This figure is three dollars per lamp. I have calculated the cost of copper per 16 candle-power 50 volt and 50 watt lamp with an average distance to the lamp of but 75ft., and with 2 per cent. loss, and found the cost of copper to be 24 cents per lamp. With an average distance of 100ft., as assumed in the case of the three-wire system, the cost of conductors for the inside wiring would be 43 cents. In making the comparisons, however, we will give them the advantage due to the 75ft distribution—that is, 24 cents. per lamp.



I have plotted these results expressing cost as ordinates and distances as abscissæ. The curves resulting are here shown. (*See* diagram). In the diagram, curve No. 1 shows cost of primary converter and secondary for alternating system (converters at $3 per lamp). No. 2 shows cost of primary and converter for alternating system. Number 3 shows cost of primary for alternating system. Number 4 shows cost of feeders for average loss of 4 per cent. Number 5 shows cost of feeders for average loss of 6 per cent. Number 6 shows cost of feeders for average loss of 8 per cent. Number 7 shows cost of feeeders and mains for average loss of 9 per cent. Number 8 shows cost of feeders and mains in the three-wire system for average loss of 6 per cent. Number 9 shows cost of feeders and mains in the three-wire system for average loss of 8 per cent.

In the three-wire system curves for total cost are the lines in black just above the dotted lines. It will be seen that if the three-wire system be operated at an average efficiency of 92 per cent. in the feeder, which corresponds to the highest efficiency claimed for the alternating-current converter system, the total cost per lamp would be equal when the average length of feeder was 6,000ft. An average length of feeder of 6,000ft. corresponds to circular area 18,000ft. in diameter—that is, about 3½ miles in diameter. In practice, it is preferable to operate at higher efficiency, making a large investment in copper, which has the strong recommendation of having the least depreciation, and requiring the least attention of anything used in connection with the transmission of energy.

The middle curves represent an average efficiency of 94 per cent. in the feeder—that is, an average loss of 6 per cent. in the feeder. You will notice that even with this superior efficiency the three-wire system is cheaper per lamp than the alternating-current converter system at an average length of feeder of 4,750ft., corresponding to circular area of 12,000ft. in diameter,

and that for shorter distances the cost rapidly diminishes—the cost of conductors for three-wire system at this efficiency with an average length of feeder of 3,000ft. corresponding to circular area of 9,000ft. in diameter, being less than one-half the cost of conductors and converters for the alternating system.

Even with the very high efficiency of 96 per cent. in the feeder, or an average loss of but 4 per cent. the conductors of the three-wire system are cheaper than the conductors and converters of the alternating current converter system for an average length of feeder of 3,600 feet or less, and this corresponds to a circular area of 11,000ft. in diameter.

Suppose that both the generator and converter are so much cheaper than we have assumed as above that it makes a total reduction of one dollar per lamp. We then find that under conditions of equal efficiency, 82·9 per cent., the three-wire is cheaper where the average distance to lamps is one mile or less. With the usual efficiency for the three-wire system, 84·7 per cent., it is the cheaper for an average distance to lamps of 4,000 feet or less, and with the highest efficiency, that is 86·5 per cent., with average loss of 4 per cent. in the feeders, the three-wire system would be the cheaper when the average distance to lamps is 3,000 feet or less.

Suppose, on the other hand, that the incandescent lamp be doubled in voltage and increased 25 per cent. in economy; at the same time that the cost of converter was reduced to two-thirds its present cost, and we find that with the highest efficiency, 96 per cent. in the feeders, the three-wire system would be the cheaper for cases where average distance to lamps is 8,000 feet or less, which corresponds to a circular district about five miles across.

Before leaving the question of economy of operation let us look at the question of depreciation. In any dynamo the depreciation naturally becomes greater when it is operated at high E.M.F., even where the type is the same, and in the high E.M.F. alternating current generator there exists the greatest tendency toward troubles due to the breaking down of the insulation of the wire on the armature. The secondary circuit of the alternating current system and the inside wiring of the three-wire system would have a similar depreciation, but there is a great difference between the depreciation of copper conductors carrying low E.M.F. continuous currents and the depreciation of highly insulated conductors carrying a high E.M.F. alternating current together with the depreciation on an expensive piece of apparatus like the converter, the large proportion of the cost of which is represented by labour. Try to compare the value of copper 20 years hence which costs $1,000 to-day with $1,000 of converters, and small highly insulated wire such as is used in the primary circuit of the alternating system, and I think it will be evident that the depreciation of the alternating system is going to be many times that of the three-wire system.

Reliability.—In ordinary practice in the three-wire system every lamp is partially supplied by every feeder on that side of the system. That is, the current can flow out on any such feeder and through the network of mains, and finally reach the individual lamp. Similarly, every lamp is supplied in part by every dynamo operating in multiple arc on that side of the system, so that the larger the system, the more reliable it becomes; and an accident to an individual main, feeder, dynamo belt, or engines, does not in any way affect the operation of the light, and in the worst event trouble in an individual building would only result in half the lamps on that circuit going out, and the other half would be scattered alternately among those which would go out, so that the result would not be even troublesome.

Now how about the alternating system? Thus far they have not found it practicable to operate their generators in multiple arc, and it is not likely that they will ever be able to in common practice. This means more than is generally appreciated. Every lamp burning on an alternating system depends upon the continuous operation in unison of six separate appliances, each of which is liable at any moment to cause an instantaneous extinction of the light in question. These six things are:—First. The individual secondary circuit which supplies the lamp. Second. The individual converter which supplies the lamp. Third. The individual primary circuit which supplies the lamp. Fourth. The individual generator which supplies the lamp. Fifth. The individual belt for the generator. Sixth. The individual engine which supplies the power.

The next best thing to reliability is ability to reduce the time the light is out to a minimum, and to accomplish this it becomes necessary to install a spare system of conductors which are only brought into service when a primary circuit gets into trouble. An expensive switchboard in the central station also becomes necessary, so that in case of trouble to a generator its load can be thrown over to another generator with the least possible effect upon the lights that the generator has been supplying. The secondary circuits from one primary can be multiple-arced, and this is sometimes done, and this adds somewhat to the reliability of the light; but the expense due to this connecting of converters by heavy wires required by 50-volt lamps makes it impracticable in usual instances.

Unless the alternating current generators are operated in multiple arc the reliability of the alternating system cannot be as good as that of an arc light system, and we all know how reliable that is.

Variety and Value of the Possible Sources of Revenue.—We now come to the consideration of the variety and value of the possible sources of revenue. The first and most important revenue for a central lighting station outside of the light itself is power.

In a central station running night and day the cost of generating additional power beyond that required for the light is quite small, probably not exceeding 30 dols. yer horse-power per year for ten hours per day. This amount of power distributed in small units as required in practice will readily sell for 100dols. per year. Owing to the fact that a large number of small motors, varying in their requirements as to power from moment to moment are supplied from one common source, a certain production of horse-power will supply the demands of motors representing a total maximum horse-power some two and one-half times as much as is produced. In other words, for every horse-power produced at 30dols. you can sell two and one-half at 100dols. each; or you can sell for 250dols. what it has cost you 30dols. to produce. It goes without saying that the ability to supply such demands is of the utmost importance to a central station. The continuous-current system is well adapted to the supply of power for any and all purposes. No practical method of operating a motor by means of the alternating current has as yet been devised, and the problem presents great difficulties, principally on account of the necessity of a comparatively continuous current for charging the fields and the instability of the torque of such a motor.

We are promised great results and extended use of the storage battery, and undoubtedly it will be used considerably for a great many purposes, therefore there is a large possible revenue from this source, which the alternating system will not be able to supply.

Then there is almost unlimited number of applications of a continuous current on a small scale for such purposes as fire alarms, burglar alarms, distribution of time, annunciators, tickers, electro-plating, telegraph lines and telephones, all of which rely upon a continuous current; and there are innumerable applications which will soon develop consequent upon the absolute reliability and constancy of the electrical pressure at command. Out of the numberless applications of the electric current which we see daily, I can think of no commercial application except the production of light and heat, for which the alternating current under discussion is available, and the production of heat by the electric current does not present a flattering outlook as a source of revenue to the owners of central station plants. Therefore, we see that to-day the alternating system is dependent for its revenue upon the sale of light alone, while the continuous current is applicable to almost every conceivable use to which the electric current is put.

Safety to Life.—The safety to life of the three-wire continuous current system using about 280 volts as a maximum E.M.F. is undoubtedly absolute. It is impossible for a consumer of such a system to injure himself by the shock in any conceivable way, and a slight burn in case he makes a short circuit in too close proximity to some portion of his person is the worst result possible, and this is almost an unheard of possibility. It has been conclusively proven in practice that the 1,000 volt alternating current is fatal to human life, and will kill a horse. Although perhaps not likely to occur, is is always possible for the primary and secondary to get into contact, either in the converter itself, or possibly in circuits outside of it. Any person handling the wires of the secondary, and a fairly good ground, is then liable, through a possible ground elsewhere, to be instantaneously killed. The most dangerous thing is the one which is usually perfectly safe, and occasionally dangerous; as is witnessed by the death of a telephone operator at Pittsburgh recently. While he was, as usual, handling various contacts about the switchboard, a high electromotive force circuit became closed somewhere outside with the telephone line, and without the slightest suspicion of any possible danger he was instantly killed in doing what he had done thousands of times before.

Effect Upon Existing Property.—The low E.M.F. of the ordinary three-wire system, the perfect protection from excessive current effected by the safety devices in use and the continuous character of its current, render it practically inert as far as its influence upon existing property is concerned. That the alternating system, with its high E.M.F. and its strong inductive influence, will occasionally cause serious trouble to existing telegraph, telephone, and other lines which it is adjacent to, seems inevitable.

From the foregoing comparisons, I consider the alternating current is not applicable to central station lighting, as it is at present operated, except as a possible adjunct, or else upon an extremely small scale in cases where a few lights very greatly scattered are required, and where power is cheap. In cases where cheap power exists at a distance of several miles from a town capable of supporting a station of 2,000 lamps and upwards, high initial E.M.F. becomes both desirable and necessary, but the continuous current converter, which already exists in several forms, and which is receiving the attention of the best

electricians and inventors of the world, will, in my opinion, be the device to supply this demand, and that very shortly.—*Western Electrician.*

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

DISCUSSION ON MESSRS. KAPP AND MACKENZIE'S PAPERS ON "TRANSFORMERS."

(Concluded from page 262.)

Mr. Esson said: In dealing with this problem Mr. Kapp had introduced the graphic method, which was always a great boon to the engineer. Throughout his investigations, however, Mr. Kapp assumed that the electromotive force impressed in the primary, or rather the electromotive force generated by the dynamo, was a sine function of the time. But surely in modern machines, with iron cores in their armatures, that was not quite the case. He could believe that in a Siemens dynamo the curve would be a sine function, and also in a Ferranti dynamo the deviation might not be great, but in a dynamo having an iron core in its armature, he could say most decidedly it would not be a sine function, nor would it be anything approximating to a sine function. He had endeavoured to map out the magnetic field in a dynamo something like Mr. Kapp's own design, where they had a disc armature with sets of poles on each side. The result was shown by a diagram, where the curve of sines was shown, and the curve got from the dynamo in the latter. They would see the flat part in the middle. That part might be a little too long in the diagram, but its length depended entirely on the construction and the proportions. The point regarding the degree to which the core of the transformers could be saturated was most interesting. From Mr. Kapp's investigations it seemed that the number of C.G.S. lines was only one-half of what could be employed in the armature of the continuous current dynamo. He would like to know the usual weight of transformer per 60 watt lamp, and also how many volts he got per foot of conductor. In the Westinghouse transformer, he believed, they got 2 volts per foot. There seemed to be very little difference in the construction of the transformers, excepting that the object in some cases appeared to be variation rather than an improvement. He thought the transformer of Mr. Kapp had an advantage over others, inasmuch as it could be taken to pieces. Leaving transformers and coming to the distribution, it seemed that here there was some little room for discussion. He understood Mr. Bernstein to advocate the series system, and in his paper Mr. Mackenzie showed himself rather favourably disposed towards it. It appeared that putting a constant current in the primary they had a current which was practically constant in the secondary, and therefore the arrangement was admirably adapted for lighting lamps in series. So far, then, as self-regulation went, there was no difference between the two systems; but when they came to the question of cost he thought that the conductors would cost more, in any case, in the series system than it would in the parallel system. They had to keep the same section of conductor right through the system. If they had to go down 100 yards to light a single lamp, they would still carry a heavy conductor with them wherever they went; and although Mr. Kapp said that in sparsely-populated districts the cost would be less, he himself could not quite make out how it was. In conclusion, he had been very much puzzled by the last sentence in Mr. Kapp's paper. He was not quite sure whether it was intended to be prophetic or not. If Mr. Kapp thought that they really would get batteries sufficiently improved to render lighting by continuous currents possible in the future, it would be a great pity, though having the conductors all right, to find at the generating station dynamos of the wrong kind, and the transformers also useless. He therefore advised Mr. Kapp to give up the alternate-current system, to put in at the generating station high-tension dynamos, and to use continuous current transformers at the sub-stations. He would then be ready, on the contingency of a good battery arising, to supply by storage. He could either charge his accumulators direct from the central station, he could charge them through his transformers, or work the lamps from the transformers. He (the speaker) did not say that the system of working with a continuous current transformer would be quite of such high efficiency as the alternating transformer system. Neither would it be so low as working from accumulators, as Mr. Crompton advised, but it would be somewhere between the two, and the accumulators would be simply used as a stand-by. They would be charged occasionally, just to make up the leakage.

Mr. Sidney Evershed also referred to the sine function. Mr. Esson had been good enough to give the meeting a diagram of one curve, which showed what a complicated function a modern dynamo might give. The Westinghouse dynamo was also supposed to give—not a sine curve but something like a zigzag of straight lines. The only way he could see of attacking that problem was to assume that it was a hyperbolic function; but he could only echo Mr. Kapp's wish, that some one with the necessary mathematical attainments would investigate the subject. Dr. Fleming described a large wattmeter, which apparently gave very inaccurate results. There was really no need for a wattmeter to be large. If Dr. Fleming were to make a wattmeter like those beautiful instruments which he showed at the meeting last year, and employ a few ampere turns—say, two or three on the pressure coil, and a large number, 100 or so, on the current coil—they would have an instrument in which there was practically no lag in the pressure coil, and consequently it would give the mean of the true instantaneous watts.

Prof. Perry said he should like to say a word or two upon this matter of the sine curve. It had been said by Mr. Esson and by Mr. Evershed that the curve was not a true sine curve, and therefore that Mr. Kapp's theory must be wrong. Before, in that room, he had made a correction of such statements. He understood that Mr. Esson measured his field—the field of the dynamo machine—to get this particular curve. If they got Mr. Esson's curve for the field, then the current—the primary current—would obey very nearly the sine law, and the law of the secondary from the transformer got nearer to a sine function still. The effect of self-induction and mutual induction was that they took out the minor ripples. A curve like that of Mr. Esson's was built up in this way, of several sine curves of different periods. A combination of one sine curve and its harmonics would give the curious curve that Mr. Esson described. They found that if they had one sine function of a certain period, another of twice that period, and others three times that period, they could get exactly what the effect of self-induction was in toning down the ripples or the harmonics. It depended on the self-induction. All those ripples were toned down, and the quicker ripples toned down very much more rapidly than the slower ripples in passing through the transformer, and he did not think it was possible by any method of measurement to get anything very different from a true sine curve in the secondary current. Mr. Esson, Mr. Evershed, and others had said that there was not a true sine curve. Well, then, there was a way of testing it and the way of testing it would be this:—Let them take a dynamometer, and send the alternating current through the thick wire coil only. Then let them take the fine wire coil, and have a little battery with a make and break, and let that make and break be controlled in some way so that they could readily vary the rate of vibration—the rate of vibration, say, of some tuning-fork. Let it be varied, so that they could measure the rate of the make and break. The main current might have any amount of ripples in it that they liked to assume. Now when the rate of alternation in the fine wire coil reached the fundamental rate of alternation in the current coil, and then only, they would have attraction between one coil and the other. If the main current had no other rate of alternation than that, according to Fourier's theorem they would have no action of the one coil on the other, except at that one rate of vibration. So that by changing gradually their make and break—changing it to quick from slow—they looked out for an indication. And when their readings on this instrument were greatest, when they knew they had got the alternation of the main wave—the main alternation of the current—they had got their main wave then, but they had not got any of the ripples. They now continued to quicken their make and break, made it quicker and quicker, and when they got to twice the rate of vibration they would probably see some indication. If it was small it meant a small ripple of twice the ordinary alternation rate. Well, let them measure what it was, then go quicker and quicker till they got about three times the first speed. They would probably get another indication. Probably there was some period which had a pretty big effect. If he was right, however, in what he had been saying about the toning down of the ripples, they would not get much indication at any other speed than the one speed which indicated the main wave. It was easy to take the results and combine the measured fundamental wave with its measured harmonics, to find the real shape of the current function. It would be known to members that if the coils were at right angles to one another mutual induction would vanish and no error could arise from this cause.

Mr. Mordey thought there was no doubt whatever, from what had been seen on the other side of the Atlantic, that transformers had a great future before them. Mr. Crompton said that the bottom would be knocked out of his argument if it could be shown that small alternating-current dynamos could be used, and could be put in parallel. It was easy to knock the bottom out of the argument. In the United States machines were being run in parallel not only in one large station, but it had been done across rivers. A station on one side of a river is supplying mains connected with a network on the other side, as well as on its own side; and when it is necessary to put more power on the mains, the dynamos on the other side of the river are switched in. He did not think there was any serious difficulty. There was one objection he would like to make to the conclusion of Mr. Kapp's paper, and that was as to the use of low-tension networks with transformers. It seemed to him that the great advantage they had in transformers was that they got rid of the enormous cost of a low-tension network. Everybody had known that the cost of the copper in a low-tension distribution system had been a very serious item on the whole. It seemed to him that as transformers regulated so perfectly, and as they could be made to regulate even more perfectly than they did just in their simple state, and as they were undoubtedly very efficient indeed for small loads, and further, as loss in the main conductors could be at a practically small cost rendered of no practical effect whatever, it seemed to him that they got rid entirely of any necessity for the distribution network. They only wanted a distribution network that would help one part from another when the wires of any one part were not sufficient to carry a full current. He disagreed as to the danger of having separate transformers for every house. It might not be necessary to put them in every house, but he certainly thought that if some simple arrangement were made for cutting out a transformer when anything went wrong with it, it was the very best thing they could do. They might put a number of transformers right along the mains, and just one house would be cut out, and no more, when the transformer in that house went wrong. He even went so far as this, that in a big house like a hotel he would run the mains round outside the buildings; he would take the wires in at two or three places from the outside, and put transformers at those points. To that extent, perhaps, a network system might be used—that is, with the inexpensive primary rather than the expensive secondary conductors. With regard to the employment of series or of parallel systems of connection he thought the advocates of the series connection of transformers forgot two difficulties. One was that the regulations of the constant-current system with an alternating-current dynamo was not at all easy. He did not know that that had been done yet. They could

they were doing full work. It was clear that for all purposes of distribution transformers were the order of the day, whether by alternate currents on the one hand, or by accumulators, or in the third case by motor dynamos. It was clear that they had to study this question of transformation in all its bearings for the basis of immediate distribution.

Mr. Kent said, there are three distinct ways of obtaining self-regulation when the primary coils of the transformers are in series.

1st. By putting all the lamps in series on Mr. Bernstein's system.

2nd. By the use of what have been called our "choking" coils, or what we prefer to call "impedance" coils.

3rd. By building up the transformer in sections so far as the core of the secondary is concerned, and connecting each lamp or group of lamps to its separate section.

The first and third of these methods is admirable for small or medium-sized transformers, and the third will do for any size. All three are perfectly self-regulating.

Mr. Kapp, in reply, said that in the first place he would answer Prof. Silvanus Thompson as to the difference between the core transformer and the shell transformer. The shell transformer had one set of coils and two cores or more. A core transformer had one core and two sets of coils or more. Now, as to Mr. Wright's contention that the shell transformer was superior. He quite agreed with that gentleman, and that was the reason why he made a shell transformer. He did not say the Zipernowski was superior; he said it was inferior. It was a shell transformer of a circular ring type. It might interest Mr. Wright to know that what he arrived at through calculations Zipernowski had found out by experiment. He had abandoned the Zipernowski type of transformer, and now made ordinary Gramme rings. Mr. Mordey suggested a very interesting experiment. The angle of lag in one or two of his (Mr. Kapp's) diagrams was so small that the cosines had such values as ·999; so that they might imagine they could not get an appreciable difference in the readings. Probably there was a difference, but the error of the measuring instrument was greater than the difference. As to the cost of the network, he objected to putting transformers into houses simply on the ground of safety, and he thought whatever they did that they must study the safety of their customers before the coal bill and before any other consideration. If they adopted the principle of distributing the secondary currents by means of a proper network, once they had laid it down, they could use it when that happy time arrived when they could employ the battery system. He would now deal with Mr. Gordon and Mr. Crompton. When he heard those two gentlemen speak he began to feel very doubtful whether, after all, they were not all of them going on a wrong line; but then he was comforted with the idea that supposing even such a man as Edison, or Brush, or Westinghouse had been present, and had seen Mr. Gordon's diagram, he would have gone home disheartened, and resolved never to put up a central station again because of the enormous consumption of current when the people had gone to dress for dinner. But what was the fact? How many battery stations were there in the world? He knew of absolutely only one in London, one in Berlin, and one in Vienna. How many central stations on other systems were at work he was afraid to say, but he thought in America there was something like 1,000. On the Continent of Europe there were perhaps 100 or 150. In England there were perhaps fifteen. All these were working on the direct system, and their machinery must be capable of supplying this extra spurt shown on the diagram. But that was a bad case. In reality they could only have that effect when they lighted the same class of houses throughout a district; but in London they never had a district so defined. They had residential mansions, and within a stone's throw they had mews and shops, all within the area which would be supplied from one station. That being the case, they would never have to meet such a state of things as Mr. Gordon suggested. If they had to meet it all they would have to do would be to make some allowance in their machinery. In what way was Mr. Crompton better off than they were? He had to supply this extra amount of light from the batteries instead of from the machines. They would have to put up more cells, and it was the battery which cost the money, not the engines. He was not against batteries in any way. He would hail the day when they could get a good battery, but all the arguments used by Mr. Crompton and Mr. Gordon might have been used with equal consistency three years ago. They had batteries then, and they had very good direct-acting steam engines and dynamos. Had they good enough batteries now? He had not seen them. The batteries which were at the Colonial Exhibition gave an efficiency of under 60 per cent. They were in the hands of experts. Everything was done that could be done. They were under supervision all day long, and yet there was only 60 per cent. efficiency. When it was said that transformers were bad because they had a low efficiency when the output was very small, they must remember that they could work up to 90 per cent. efficiency at a moderate output, and 96 per cent. at full output. He maintained if they put down a network of mains and employed transformers to feed them no transformer need work at less than a third of its output (where its efficiency was 85 per cent.), for the simple reason that when the output got less they could cut off a feeder and let the network be fed from the others. He would now like to say one word about the question of dynamos. He thought they would go away frightened at the size of the alternate-current machines if they took Mr. Gordon's figures, who spoke of a machine giving 200 kilo-watts, with an armature 10ft. in diameter. Now, the machine which was shown last Thursday on the board was of 60 kilo-watts, and the armature was 40in. diameter. If they built a machine on the same lines with a 6ft. armature it would give them 200 kilo-watts, and the machines would weigh about 80lb. per horse-power, which was less than a continuous-current machine. Several speakers had spoken about magnetic lag. He would be a bold man who said whether there was or there was not, because nobody had proved it; but he thought there was not, and his reason for so thinking was that if there were lag he could not see how any telephone could articulate. If there were lag, the lower the voice going through the telephone the better they ought to hear. Now, as a matter of fact, they heard a high voice better than a low voice. The high voices have quick waves, and should be more distorted by lag, but they were not more distorted, and for this reason he was inclined to think that there was no lag; and until somebody showed him actually by experiments that that opinion was wrong he should hold it. Captain Cardew and Mr. Bernstein had objected to the safety device which he put between the two coils, and Mr. Bernstein had characterised it as leading the primary current into temptation. Now, what was this temptation? It consisted of the presence of metal outside the primary current; but between this metal and the coil there was insulation. In what did this differ from the temptation which existed in every transformer? They had the metal in the secondary coils, and they had insulation between them and the primary. With the core itself it was just the same thing. And in what way was the strain brought on the insulation of the primary greater on account of this shield, as compared with the strain which was already brought on it by the presence of the core? They were bound to have iron somewhere, and whether they had it in the inside only, or on the inside and outside as well, the strain on the insulation was the same. So that he believed the objection was merely a sentimental one. Referring to the general question of batteries *versus* transformers he wished them to understand that he was at present in favour of the latter, simply because he had no confidence in batteries. If he knew batteries were good enough he would never presume to put down alternating plant; but he had never seen a good battery, and, therefore, that was the only way of doing the work. It was done everywhere. As Mr. Mordey said, they might as well try to stop the sea as try to stop the employment of alternate currents. But in order to provide for the day when batteries would be good enough, they must put their plant down now so that most of it could be used later on. What would they have to throw away, and what could they retain? They could retain their boilers, engines, and stations. They could retain the whole of the network, and the whole of the distributing plant to the houses. What they had to throw away were their alternating dynamos and the transformers. Both together would not cost more than 10s. a lamp. The wiring and fitting of each lamp in a private house would cost at least 30s. to 35s.; the conductors would cost something like 30s. again; so they could see that by introducing alternating currents they would only risk a possible future sacrifice of about 10s. per lamp in an installation costing from £3 to £5 per lamp originally. Nearly the whole of their plant would remain equally serviceable when the day arrived that batteries could be used. Until then they would find the alternate-current and transformer system good enough, safe and reliable for all practical requirements. It seemed to him that there really was no fault to find. They did not advocate a thing which was altogether wrong, and which would be altogether wrong in a few years. They advocated a thing which with a very little sacrifice would be good for the day when they had batteries.

Mr. Mackenzie said, in reply to Prof. Ayrton's query as to whether the coils he spoke of were ever seriously tried at the Grosvenor Gallery installation, he could only say that some experiments had been made with an apparatus consisting of a single coil of fine wire placed in shunt to the primary of the series transformers then being used, in which coil was inserted a core formed of a bundle of iron wires, inserted more or less by hand as the output from the secondary of the transformers varied. No good results were, however, obtained, as the coils that were tried invariably got burnt up in course of time. The idea was abandoned, and no further experiments were made, it being decided about that time to put the transformers in parallel. Mr. Bernstein had suggested that his fusible contact plugs would serve as a means of putting the secondaries to earth should the potential rise above what was proper, and he (Mr. Mackenzie) thought that such an arrangement was quite feasible, and would prove cheaper than the apparatus devised by Captain Cardew, which was, however, in itself an excellent an ingenious contrivance; but he objected altogether to putting the secondaries to earth in an installation based on the transformer system, for reasons which were numerous, and had already been mentioned by previous speakers. Mr. Atkinson, in referring to the Kingdon dynamo, wondered whether he (Mr. Mackenzie) had experienced in working this machine a large amount of alternation in the exciting circuit; and this effect had in reality been observed, though not to any great extent, and was probably due to the causes mentioned by Mr. Atkinson. Mr. Kingdon, in stating that the fly-wheel of an engine would form part of his machine, did not intend to convey the impression that existing engines were preferably to be so altered; but that in designing a dynamo for a central station, the fly-wheel of the engine, necessary to insure in any case steady running, would be made to form part of the dynamo, and thus combine two functions in one. The object of arranging the machines into various circuits, so as to admit of alterations in the coupling, was obvious, since bobbins could be cut out of circuit as the output diminished, thus working the remainder at their maximum. There were many reasons why it would be advantageous to be able to alter the connections of the bobbins, but the want of time prevented him going into the matter.

In answering Mr. Crompton's request to give him information regarding the efficiency of the transformer system, he thought that Mr. Crompton was at present asking for rather too much. As regarding the saving of copper used by the employment of this system, reference to the diagram on the wall would make this clear; and he thought that many of the objections that had been raised by Mr. Crompton had been met and successfully answered by several speakers that evening. There would be no gainsaying the fact that the transformer system had made tremendous way, and this would never have been the case had not the system possessed merits placing it before all others for the general distribution of electricity. He quite expected to see Mr. Crompton before very long becoming as warm an advocate for the transformer system as he had not many years ago been an opponent of electrical distribution by secondary batteries. Mr. Gordon had gone very fully into the relative merits of the two systems, but he had been

answered by several gentlemen who had joined in the discussion that evening, and the speaker was afraid he could not altogether agree to the conclusions Mr. Gordon had arrived at. Prof. Sylvanus Thompson, as well as Mr. Mordey and Mr. Madgen, had called attention to his statement regarding the Faradaic theory. He wished to point out that the words "*and* exemplified by Ruhmkorff" should be "*as* exemplified by Ruhmkorff," M. Gaulard never having dreamed of denying the Faradaic theory of induction, as such would have been absurd on the face of it; but he distinctly laid down the dictum that the Rhumkorff coil more or less modified formed the basis upon which all previous experimenters had worked, and had consequently been utterly unsuccessful. Regarding Mr. Madgen's mention of Jablochkoff, he denied that that electrician had ever conceived the idea of a transformer system as now existed. He quite recollected the apparatus exhibited by M. Jablochkoff in Paris at the great International Electric Exposition of 1881, but the system then shown at work as a "transformer system" was no more—either theoretically or practically—like what Gaulard had discovered than a Wimshurst machine was like a dynamo, and he did not think the subject worth discussion. Prof. Thompson had objected to his statement that when one transformer only was connected to a dynamo it was "either in parallel or series," but he did not see how any one could prove the contrary, in spite of the argument brought forward by the Professor, since like a "quarrel," it took more than *one* to make a parallel or series circuit. Seeing the hour was so late, he was unable to say more in answer to the remarks made by the numerous gentlemen who had joined in the discussion.

PROVISIONAL PATENTS, 1888.

MARCH 17.

4144. **Improvements in or relating to mariners' compasses.** Thomas Harrison, 6, Lord-street, Liverpool.

4153. **Improvements in means for regulating or controlling the secondary current derived from continuous electric current transformers.** Frank King, 47, Lincoln's Inn-fields, London.

4171. **Electrical governor for motive power engines.** William Spiers Freeman, Gray's Inn Chambers, 20, High Holborn, London, W.C.

MARCH 19.

4177. **Improvements connected with insulators for the purpose of regulating the tension of telegraph and telephone line wires.** Edward Baines, Commercial-street, Halifax.

4188. **An improvement connected with arc lamps whereby the controlling mechanism is contained in a box four inches deep or thereabouts.** Frederick John Beaumont, 42, Trinity-square, Boro', and John Kent, 9 and 10, Railway Approach, London Bridge, S.E.

4208. **Improvements in apparatus for opening doors by pneumatic or electrical agency.** Carl Wilhelm Friedrich Thode, 22, Southampton-buildings, Chancery-lane.

4222. **A regulating appliance for dynamo-electric machines worked by gas motor or other engines.** Henry Percy Holt, 28, Southampton-buildings, Chancery-lane, London, W.C.

MARCH 20.

4240. **Improved apparatus for the making and breaking of contact in electrical appliances, especially applicable for burglar alarms, and instead of pushes for ringing electric bells.** Henry Bowditch Yardley, 17, Clarendon-villas, Church-lane, Old Charlton, Kent.

4270. **Improvements in the method of and apparatus for controlling or regulating the movement of electro dynamic motors, or of machinery or apparatus propelled or driven thereby.** Bradley Allan Fiske, 23, Southampton-buildings, Middlesex.

4274. **Improvements in or relating to storage batteries.** William Phillips Thompson, 6, Lord-street, Liverpool. (Chas. David Paige Gibson, United States.) (Complete specification.)

4275. **Improvements in or relating to storage batteries.** William Phillips Thompson, 6, Lord-street, Liverpool. (Chas. David Paige Gibson, United States.) (Complete specification.)

4292. **An improved switch and fuse for electric light and other purposes.** Claude Edward Gillet Gilbert, 79, Amhurst-road, Hackney, E.

4294. **An harmonic commutator for alternating currents.** Ambrose Myall, 21, Cockspur-street, Middlesex. (Walter Judd, Hong Kong.)

MARCH 21.

4317. **An electric lamp and bell, and improvements in electric lamps.** Japh John Mason, 5, St. Mary's-street, Lincoln.

4330. **An improvement in dynamo-meters.** Paul Fuess, 47, Lincoln's Inn-fields, London.

4345. **Improvements in the method of and apparatus for distributing electrical energy by alternating currents from central stations.** Gisbert Kapp, 70, Market-street, Manchester.

4353. **Improvements in electric telegraph insulators, and in the manufacture thereof.** Ernest Wentworth Buller, 33, Queen-street, London, E.C.

MARCH 22.

4393. **Improvements in and relating to the control of electric currents.** William Spiers Freeman, Gray's Inn-chambers, 20, High Holborn, London, W.C.

4425. **Improvements in dynamo-electric machines or motors.** Patrick James Charles, Luther Hanson, and Robert Henry Fowler, 24, Southampton-buildings, Chancery-lane, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MARCH 18, 1887.

4116. **Improvements in electric incandescent lamps, and in the method of manufacturing the same.** Arthur French St. George and Christen Riis Bonne, 26, Mark-lane.

MARCH 31, 1887.

4795. **"Direct motor wheel" for the driving of carriages, dynamos, or machinery.** Frederick Fawson Lee, The Close, Salisbury.

APRIL 22, 1887.

5862. **Simultaneous driving of a number of clocks by magneto electricity.** William Blenheim, Englefield Green, Egham, Surrey.

APRIL 23, 1887.

5958. **Improvements in dynamo-electric and magneto-electric machines.** Alexander Melville Clark, 53, Chancery-lane, London.

MAY 9, 1887.

6754. **Improvements in and connected with dynamo electric machines.** Rookes Evelyn Bell Crompton and James Swinburne, Arc Works, Chelmsford.

MAY 11, 1887.

6917. **Improvements in electric transformers induction coils, or inductional resistance coils.** William Morris Mordey and Charles Edmund Webber, 47, Lincoln's Inn-fields, London, W.C.

MAY 12, 1887.

6987. **Improvements in electric arc lamps.** Alexander Siemens, 28, Southampton-buildings, Chancery-lane, London, W.C.

MAY 13, 1887.

7021. **Improvemenss in electro-dynamic and dynamo-electric machines.** George Scarlett, 6, Lord-street, Liverpool.

NOVEMBER 4, 1887.

15,056. **An improved multiple electric cable.** James Alexander Betts, 53, Chancery-lane, London.

JANUARY 12, 1888.

506. **Improvements in the construction of suspension fittings for incandescent electric lamps.** Charles Mark Dorman and Reginald Arthur Smith, 24, Brazenose-street, Manchester.

JANUARY 17, 1888.

750. **Improvements in and relating to electric railways and to vehicles for use thereon.** Henry Harris Lake, 45, Southampton-buildings, London. (David Gustavus Weems, United States.)

SPECIFICATIONS PUBLISHED.

1887.

2819. **Electric lamps.** H. Nerlinger. 8d.

2825. **Dynamo-electric machines.** J. G. Statter. 11d.

2954. **Gearing for traction, &c.** M. Immisch. 8d.

4549. **Electric incandescent lamps.** A. Featherstonhaugh. 4d.

5199. **Distributing electric energy for locomotion.** W. Lowrie and C. J. Hall. 8d.

5303. **Dynamo electric machines.** H. W. Ravenshaw and others. 8d.

5505. **Dynamo Electric Machines.** W. H. Ravenshaw and others. 8d.

5637. **Electrical controlling apparatus.** A. Siemens and E. F. Lauckert. 8d.

5833. **Combined gas motor engine and dynamo-electric machine.** W. F. Crossley. 6d.

5835. **Contact makers.** L. D. Selby-Bigge. 8d.

9731. **Ammeters.** W. P. Thompson. (Westinghouse.) 8d.

14,204. **Medico-electrical apparatus.** J. R. Hard and T. Wilson. 8d.

1888.

1078. **Switches for electrical circuits.** S. Bergmann and J. T. Dempster. 8d.

1881.

562. **Carbon burners, &c.** P. Jensen. (Edison). 11d.

1918. **Carbon conductors for electric lamps.** E. G. Brewer. (Edison). 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.	Dividend.		Name.	Paid.	Price. Wednesday
3 Jan.	4%	African Direct 4%	100	101	1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105x
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼	28 July	10/0	India Rubber, G. P. & Tel.	10	16⅞x
12 Feb.	2/0	— fully paid	5	4¼	28 Oct.	12/6	Indo-European	25	40
15 Feb.	10/0	Anglo-American	100	39	16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
15 Feb.	20/0	— Pref.	100	65	16 March ...	5%	Maxim Weston	1	3-16
12 Feb., 85...	5/0	— Def.........................	100	15	15 May	5%	Oriental Telephone	11	½
29 Dec.........	3/0	Brazilian Submarine.........	10	12	14 Oct.	4/0	Reuter's	8	8¼
16 Nov.	1/0	Con Telephone & Main ...	1	11-16	......	...	Swan United	3½	2½
15 Feb.	8/0	Cuba	10	12¾	15 Feb.	15½%	Submarine	100	145x
28 July	10/0	— 10% Pref.	10	19	15 Oct.	6%	Submarine Cable Trust ...	100	97
14 Oct.	1/0	Direct Spanish	9	3¾	14 July	12/0	Telegra, h Construction ...	12	39
18 Oct.	5/0	— 10% Pref.	10	9½	3 Jan.	6/0	— 6%, 1889	100	107
14 Oct.	2/0	Direct United States	20	8⅝	30 Nov.	5/0	United Telephone	5	14 3-16
12 Jan.	2/6	Eastern	10	11½	......	...	West African	10	5
12 Jan.	3/0	— 6% Pref.	10	15⅜	1 March ...	5%	— 5% Debs.	100	93
1 Feb.	5%	— 5%, 1899	100	105½	29 Dec.........	6/0	West Coast of America ...	10	5⅝
28 Oct.	4%	— 4% Deb. Stock	100	107⅝	31 Dec.	8%	— 8% Debs.	100	116
12 Jan.	2/6	Eastern Extension, Aus-			14 Oct.	3/9	Western and Brazilian	15	9¾
		tralasia & China............	10	12⅝	14 Oct.	3/9	— Preferred	7½	6⅝
1 Feb.	6%	— 6% Deb., 1891	100	106	......	...	— Deferred..................	7½	3¼
3 Jan.	5%	— 5% Deb., 1900	100	104	1 Feb.	6%	— 6% A	100	110
2 Nov.	5%	— — 1890	100	103	1 Feb.	6%	— 6% B	100	105
3 Jan.	5%	Eastern & S. African, 1900	100	104½	......	...	West India and Panama ...	10	13-16
12 Jan.	5/9	German Union	10	9¼	30 Nov.	...	— 6% 1st Pref.	10	10½
27 Jan.	1/6	Globe Telegraph Trust......	10.	5⅞	13 May, '80...	...	— 6% 2nd Pref.	10	6½
27 Jan.	3/0	— 6% Pref.	10	13⅜	2 Nov.	7%	West Union of U.S.	$1,000	125
3 Jan.	5/0	Great Northern...............	10	14¼	1 Sept.	6%	— 6% Sterling	100	101x

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Feb. ...	£38,795	+ £3,242
Brazilian Submarine	W. March 16...	£4,979	...	Great Northern	M. of Feb. ...	20,400	...
Cuba Submarine	M. of Feb. ...	3,600	+ £591	Submarine	None	Published.	
Direct Spanish.....................	M. of Feb. ...	1,858	+ 235	West Coast of America	M. of Feb. ...	4,625	...
— United States	None	Published.	...	Western and Brazilian	W. March 16...	4,181	...
Eastern..............................	M. of Feb. ...	51,261	+ 4,361	West India and Panama	F. March 15 ...	3,333	+ 55

Abbreviations: W., week; F., fortnight; M., month.

COMPANIES' MEETINGS.

DIRECT SPANISH TELEGRAPH COMPANY.

The twenty-ninth ordinary general meeting of the Direct Spanish Telegraph Company (Limited) was held on Monday at Winchester House, Old Broad-street, E.C.

Sir James Anderson presided, and said their revenue had increased by £1,338, notwithstanding the fact that their traffic on the Barcelona section had fallen off owing to the absence of speculation, therefore this traffic was nearly all due to other parts of Spain; and he might further add that the last three months of the present year showed a still further increase of £250. That was estimating the amount taking into account the Easter week, which was always a small one, so that he hoped next year they would get to a 5 per cent. dividend on the ordinary shares. It only required £600 to pay 1 per cent. on the ordinary shares, and he did not see why they should not get to the amount he had stated, seeing that the trade of Spain was improving. There had been a decrease of 10 per cent.; but what was most important, they had been able to place £8,417 to the reserve fund; £5,000 had been invested in Forth Bridge Railway Four per cent. Debenture Stock, and in Three-an-a-half per Cent. Liverpool Corporation Stock, which had increased in value £255 since they bought it. He hoped that next time they would be able to print their reserve, showing at a glance what their reserve was invested in. The directors stated at the last meeting that they were getting a direct wire from Madrid to Bilbao, and when that was finished they hoped they would get a still further improvement in the traffic. Nothing increased the use of telegraphy more than rapidity of transmission and accuracy. Their average time from Bilbao to London was only five minutes, and that left nothing to be desired, but if they got a special wire they would get through in five or seven minutes to Madrid, and then he thought they ought to have some further improvement in their trade. The company was prosperous; they were working at a very low tariff, and yet they were increasing their revenue. Last time the traffic had fallen off for the previous three months, now he had to tell them it was increasing, and but for the Easter week, which Mr. Gerhardi had estimated in the present three weeks, they would have had a half per cent. already earned. He thought in time the Direct Spanish would stand equal to any other telegraph company in the city of London. He moved the adoption of the report.

Mr. Etlinger seconded the motion, and it was carried.

A dividend at the rate of 10 per cent. per annum was declared on the preference shares, and of 2½ per cent. on the ordinary shares (free of income tax), making 4 per cent. for the year.

CITY NOTES.

Maxim-Weston Company.—The Maxim-Weston Electric Company shows a net profit for the year, including £139, brought forward, of £1,555.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended March 23 amounted to £5,094.

The Schanschieff Company.—We are informed, says the *Financial News*, that the capital of the Schanschieff Electric Light and Power Company (Limited) has been over-subscribed.

Direct United States Cable Company.—The board of the Direct United States Cable Company have resolved upon the payment of an interim dividend at 2s. per share, free of income-tax, being at the rate of 2 per cent. per annum for the quarter ending March 31, 1888, such dividend to be payable on and after April 24 next.

Globe Telegraph Company.—The directors of the Globe Telegraph Company have declared the payment of an interim dividend on the preference shares of 3s., less income-tax, and of 2s. on the ordinary shares, the income-tax having already been deducted, payable on the 18th proximo, for the quarter ending April 18, 1888.

The Schanschieff Electric Light and Power Company, Limited. A new company has been registered under this title, with a capital of £200,000 in 40,000 shares of £5 each. The directors are:—

The Right Hon. Earl Cathcart, Thornton-le-Street, near Thirsk, Yorkshire (chairman)

Wilberforce Bryant, Esq. (chairman. Bryant and May, Limited).

Lieut.-Col. The Hon. H. W. Campbell (Director, London and South-Western Railway Company).

David Marks, Esq. (Director, Northumberland Land and Coal Company, Limited).

Otto H. Trummer, Esq (Director, Bryant and May, Limited).

(All the Directors are interested as Vendors.)

The prospectus states that the Company is formed to purchase from the Schanschieff Electric Battery Syndicate, Limited, the patent rights for the United Kingdom, France, Belgium, Germany, Italy, United States of America, and India, for the Schanschieff Single Liquid Battery, and also the benefit of applications for patents in respect of the invention, which have already been made by the vendors in many other countries, together with the right to patent the invention in all other countries in the world in which patents or similar rights can be obtained, subject to the half interest reserved to the vendors in the patents other than that for the United Kingdom.

NOTES.

The "Benbow."—Like all new vessels of any pretensions, this magnificent ship is fitted throughout with the electric light.

Electric Lighting of a Theatre.—The Gas Company of Béziers (Hérault) is about to carry out the electric lighting of the theatre in this town.

United Telephone Company.—The United Telephone Company have taken advantage of the Easter holidays to make certain improvements and alterations in their switch-room.

Telephonic Development.—Mr. A. R. Bennett read a paper on recent developments in telephony at the fortnightly meeting of the East of Scotland Engineering Association last Tuesday.

Society of Telegraph-Engineers.—The paper to be read at next Thursday's meeting of the society is on "Central Station Lighting" (Transformers *v.* Accumulators), by R. E. Crompton, M.I.C.E.

Electric Traction.—An experimental tramcar has been successfully run at Paisley from Inch-street to the Cross. The electrical part of the car is according to the designs of Mr. James Gibson, of Paisley.

Electric Lighting of Trains.—The London and Brighton Railway Company have now fifteen trains lighted by electricity, two running between London and Brighton, and thirteen others which are local.

Welsh Gold Mines.—According to various reports, the returns from these mines are extremely favourable, and in order that the work may be carried on more quickly, electric light apparatus is being installed at the Gwynfynydd Mine, by means of which the mine and premises are to be lighted.

Wonderful.—An American town, Urbano, O., recently advertised for tenders for 15 to 40 arc lights and 100 incandescent lights, and maintenance for five years; but, wonderful to relate, the Town Club did not receive a single tender. Are all the companies full of work; or is there more in this than meets the eye?

Barcelona Exhibition.—The illuminated fountains, which will be an interesting feature of this exhibition, will be erected and run by the Anglo-American Brush Electric Light Corporation, who have entered into a contract with the authorities to provide fountains similar to those which excited so much admiration at the recent South Kensington Exhibitions.

Storms in Eastern France.—Violent thunderstorms have been scaring the population of Nancy and its neighbourhood, and one death—that of a farmer—is already reported. He was struck by lightning as he was returning home after his work, and his family, alarmed at his protracted absence, went in search of him His body was not found until a late hour in the evening.

Gas Sometimes Fails.— A correspondent says:—Shortly after the commencement of the service at Holy Trinity church, Boston, the other Sunday evening, the gas went out, owing to water in the pipes, and but for the candles at the reading-desk, the congregation would have been in total darkness. The gas was re-lighted but went out again almost immediately. The service was therefore abruptly closed and many of the congregation repaired to the parish church.

Exeter and the Electric Light.—At the meeting of the Exeter Town Council, last week, a memorial was read from over 3,000 citizens, asking the Council to take steps with a view to the adoption of the electric light as an illuminant for that city. One of the systems of electric lighting has been for some time in use in some of the main streets, and the citizens seem much pleased with it. The Council resolved to take steps to ascertain the cost, and various other particulars.

Telegraph Officials.—It having been brought under the notice of the Lords at the Treasury that the system of paying fortnightly the staff at the London Central Telegraph Office involved an extra expenditure of one day's pay in every ordinary year of 365 days, and of two days in every leap-year, to those of the clerks earning a yearly salary, their lordships have issued an order to the effect that in future the salaries are to be paid monthly. The gain to the Treasury would have amounted to nearly £600 for the past year.

Easingwold.—The contract for lighting the mansion of J. H. Love, Esq., The Hawkhills, Easingwold, Yorkshire, has been placed in the hands of the United Electrical Engineering Company, Limited. The installation will be a large one, consisting of about two hundred 16 c.-p. lamps. The power will be supplied from a steam engine and boiler to be erected by the contractor in a small engine house built for the purpose. A set of accumulators will be provided to keep 90 to 100 lamps running from eight to nine hours.

Bradford.—In our advertisement columns will be found an advertisement from the borough of Bradford relating to tenders for electric lighting. The action of Bradford is commendable from all points of view. The Corporation owns the gasworks, but an independent company started electric lighting, and it was seen that from many points of view the latter had possibilities superior to gas; hence, it was decided to make a practical experiment to determine the exact value of such a light and its cost for general lighting purposes.

University College, Bristol.—The Students' Engineering Society of this college concluded the winter session on March 26th with a public disputation on the gas engine *v.* the steam engine, and on March 27th with a *conversazione*. Mr. de Soyres occupied the chair on the first night and Mr. Albert Fry on the second. The electrical and engineering exhibits attracted much attention, and a highly-appreciated concert was rendered by the students and their friends. The proceedings were concluded by a short address to the departing members by Dr. Ryan, president of the society.

The Telephone in Peru.—The Peruvian Government is putting up to auction the construction and working of telephone networks over the whole extent of the Republic. The main stipulations are the following:—An exclusive concession for 15 years. Payment for the construction of lines by subscribers, according to a fixed price per kilometre. Permission to fix supports for the lines on the roofs of public buildings. Gratuitous use of a line by the Palace of the Prefecture. Tenders should reach Lima prior to the 23rd prox. Preference will be given to tenders proposing the lowest tariffs for subscribers.

Madrid.—The new regulations for the Madrid theatres were published on the 31st March. Among other things they prohibit the use of gas, and make the adoption of the electric light within six months compulsory. A large business has been done in Spain by English manufacturers in

other branches of mathematical engineering, and we trust the various electric light firms have secured good representatives in that country. The Royal decree states that all dynamos, engines and motors of any kind are to be completely isolated from the main building, and in fact stringent rules are laid down to render the installations safe. The supplementary lamps are to be oil lamps.

Civil Service Stores.—An installation of 372 incandescent and two arc lamps has been completed at the Civil Service Stores in Queen Victoria-street. The dynamo is one of Elwell-Parker's inverted B type, driven by one of Davey-Paxman's compound vertical engines of 16 h.-p. The two Essex boilers are also by Messrs. Davey-Paxman. About four miles of wire have been used, and this is cased throughout. The whole of the installation has been carried out under the direction of Mr. Goddard, chief engineer to the Civil Service Association, and has proved very satisfactory. The dynamo ran last week from Thursday morning till Saturday night without difficulty.

Phono Signals in Submarine Telegraphy.—A telephone, placed in the circuit of a submarine cable through which the ordinary signals are being transmitted, is affected by the currents passing; although the vibrating of the diaphragm may not be perceptible to the ear, for the well-known reason that a minimum of twenty vibrations per second is requisite to produce an audible sound. But if an interruptor, breaking the current more than twenty times per second, be also inserted in the circuit, an undulating sound is conveyed to the ear by the telephone. On this principle, M. Ader has constructed an apparatus which allows of the employment of phonetic signals in submarine telegraphy.

Electric Welding.—Prof. A. E. Dolbear writes :—"I have had made nearly a hundred tests of the tensile strength of electrically-welded bars of iron, steel, and other metals. The results were of such a character that I can state positively that with Thomson's welding process it is possible to weld both wrought iron and steel so that the weld is as strong as the same cross-section in another part of the bar. I had a number of bars welded by an expert backsmith and a number of similar ones by the electrical process for comparison, with the result that the electrically-welded bars were much stronger than those welded by the ordinary process. The bars were of various sizes, up to an inch and a half for iron, and three-fourths of an inch for octagon steel."

The "Star" Paragraph.—A contributor, growing satirically eloquent over the mutual admiration society referred to by the *Star*, bursts into the following verse, which he says aptly describes one man's feelings :—

"But I car'd not for that the worth of a shilling,
Well knowing my friends are both ready and willing
With proxies O.K. in support of my wishes,
While I keep the keys to the loaves and fishes.
If Nature had not on the whole of our class
Most kindly bestowed a profusion of brass,
I'd feel quite ashamed to exhibit my face
In front of the *husband;* but then there's my place;
So we'll stick to each other and cannot then fall,
For we've cheek, and we've bounce—and the chink, that is all."

The metre is somewhat shaky, but it may pass.

Kensington.—The Works Committee have considered the draft license proposed by the Kensington Court Electric Light Company, and, after conference with the engineer and solicitor, suggest the following alterations to the Board of Trade :—"In clause 7 (section *c*), authorising the carrying of the line over or across any street, the addition of the word 'bridge.' In clause 10, relating to interference with any sewer, drain, watercourse, defence, or similar work under the jurisdiction or control of the board, the insertion of the words, 'or work in connection with such sewer or drain, such as ventilating shafts, manholes, side entrances and gullies;' also a provision that any consent given by the board should be in writing." The board approved the action of the committee.

Vagaries of Lightning.—During a hailstorm at Mors, in Denmark, a few days ago, a flash of forked lightning—the only one occurring—struck a farm, and having demolished the chimney-stack and made a wreck of the loft, descended into the living rooms on the ground floor below. Here its career appears to have been most extraordinary; all the plaster around doors and windows having been torn down, and the bed curtains in the bedrooms rent to pieces. An old Dutch clock was smashed into atoms, but a canary and cage hanging a few inches from it were quite uninjured. The lightning also broke 60 windows and all the mirrors in the house. On leaving the rooms it passed clean through the door into the yard, where it killed a cat, two fowls, and a pig, and then buried itself in the earth. In one of the rooms were two women, both of whom were struck to the ground, but neither was injured.

A New Electric Launch.—A great sensation was produced on the occasion of the recent Oxford and Cambridge boat race by an electric launch, due to the Electrical Power Storage Co., and worked by their accumulators. "At last," says a non-technical contemporary, "a really useful electric launch has been produced, and the noisy, dirty accessories of steam and coal on the Thames will be reduced." The vessel can accommodate 20 people, and will attain a speed of 11 knots an hour on the tideway. The means of propulsion are not visible, for the accumulators are placed under the seats, and the motor is at the bottom of the vessel. The launch is completely under control, and by just turning an indicator handle can be driven at half or full speed forwards or backwards. Sufficient energy is stored for driving at full speed for eight hours or half speed for 18. It is proposed to erect charging stations at points up the Thames, so that launches going for a protracted trip may be re-filled.

Leamington.—Further alterations and improvements are about to be introduced by the Midland Electric Lighting Company into the lighting of the Parade. It is proposed to substitute, in place of the 16 candle-power Swan lamps now in use, 32 candle-power lamps, and to reduce the number of lamp-posts by about one-half. An alteration is also to be effected in the mode of hanging the lamps, which will not be suspended from the end of a long arm, but will be enclosed in a globe placed on the top of the supporting column. The globe will be 2ft. in diameter, the upper part opal, and the lower part frosted glass. The shape of the lamp will thus be hidden, and only the bright light irradiating from the globe on all sides will be seen. No general alteration will be made, and none is necessary, in the lighting of the shops and private houses, where the light is much appreciated. The company, however, do not bind their customers to any kind of lamp. The works in Wise-street are fast approaching completion, and Messrs. Chamberlain and Hookham are sparing neither trouble nor expense to make the lighting of the town a success

Train Signalling.—The practical value of the induction system of train telegraphy, says *Engineering News*, by which messages can be sent from moving trains, was well illustrated by its workings on the Lehigh Valley Railroad in the great blizzard. The regular telegraph lines were all down, but the induction line, which has been in use upon the New Jersey division, from Perth Amboy to Easton, for several months past, worked excellently throughout. In one accident, near Three Bridges, the induction train telegraph operator at once telegraphed back for a wrecking train, which soon arrived; and during the entire day messages were sent to and from the wrecking train, and surgical relief was obtained. All the beleagured passenger trains, every one of which was equipped with the new system, were located by means of train telegraphy, and provisions were sent to the hungry passengers. More than two hundred messages were sent back and forth over the single line of the company during the three days of the storm by belated passengers and others. The poles used to carry the line are only 16ft. high, and expose little surface to the storm. The messages are transmitted by induction from the metal roof of the car to the line, a distance of 10ft., and even when cars and line were both buried in the drifts no inconvenience was suffered, as the dry snow did not interfere with the induction.

An Amusing Telephone Story.—A funny story is told of the telephone. A cement manufacturer some miles below London Bridge was lately placed in circuit. He is rather high-tempered and easily provoked. His foreman is old, short-sighted, and somewhat dull of hearing. The latter has sometimes to go to the master's private office for instructions. The other day he saw his master was alone, and, all oblivious of the new means of communication, he stood himself on the mat outside at the open door.

Master to instrument—Halloa! What is it you want?

Man at door—I want to know how many barrow-loads of stuff——

Master to man—Will you be quiet there for a minute? To the instrument—Eh! I didn't catch what you said.

Man—It's about that stuff we've been a-workin' on, and it's time.

Master to man—Will you be quiet, will you? I'm not speaking to you. To the instrument (loud)—Repeat that, please. I can't hear well.

Man at door (louder than ever)—If you're a-going to put that 'ere stuff in, sir. We want to know——

Master to man (louder than ever)—Oh dear, will you shut up, you old fool? Don't you see that I'm engaged?

Hanging up the receiver, he slammed the door in the foreman's face. When he returned he could get no further communication. The man thinks his master was out of his mind, talking to himself in that dreadful way. The master wonders why the man at the other end didn't finish his message, and thinks the telephone's no good. The man at the other end is waiting for an explanation as to the strange replies he received when he was trying to send on an order for cement by telephone, and has placed it elsewhere.

Electric Tramway.—Some time ago, says the Vienna correspondent of *Industries*, I reported the inauguration of a short experimental electric tramway line from the Central Station along the Königsgasse and part of the Ringstrasse, the total length being 1·1 kilometres. The service on this line has now for some months been perfect. The generating dynamo is established in a shed near the railway station, and the current is supplied by means of a central channel and a pair of conductors against which slide two contact shuttles. There are at present only two cars in use. These are of the same type as those on the Lichterfelder tramway near Berlin. The transmission of power from the motor spindle to the car axle is by steel wire spiral cords. The central channel is of masonry throughout, with cast iron chairs for the support of the conductors, and has two steel rails on the top, leaving a slot 1¼in. wide. Manholes are provided in several places to give access to the channel, and efficient provision is made for draining it. Messrs. Siemens and Halske, who have built this line, are now experimenting with various forms of contact shuttle. They have asked for a concession to extend the line the whole length of the Grosse Ringstrasse, now building, and they also made an offer to the town authorities to build, and equip with electric apparates, several tramway lines which were originally projected for steam traction. In all cases they ask that the usual concession of forty years should be prolonged to fifty years, the extention of time being justified by the heavy initial outlay for the permanent way.

Carbons for Arc Lamps.—The manufacture of arc light carbons forms an industry of considerable magnitude, and the works of Herr Hardtmuth, in Döbling, says *Industries*, are now turning out about 3,500 metres of carbons daily. Some improvements have recently been made in the process of manufacture, under which the homogeneity and density of the carbons are increased. These refer more especially to cored carbons. As usual, the rod of plastic material issues from the press in the form of a tube, and after drying and baking, the carbons are steeped in a heavy hydrocarbon, by which the pores left after the first baking are filled. The carbons are again baked, and the core is then inserted under a pressure not much greater than that of the weight of the plastic mass forming the core. In connection with this factory is a well equipped electrical laboratory for the testing of arc lamps. There are dynamo machines by various makers—viz., Pöge, of Chemnitz; Kremenezky, Mayer, and Co., of Vienna; Krizik, of Prague; and Siemens and Halske (alternator). The reason for installing various dynamos is to be able to test any lamp which may be sent to the laboratory. There is also a spectroscope for determining the elements contained in the carbon from the spectrum of the arc, and the laboratory is equipped with the usual electrical measuring instruments and photometers. The work at this laboratory is done on a thoroughly scientific basis, and both lamps and carbons are tested so as to determine the best quality of carbon to be used for each type of lamp. At the forthcoming Jubilee Exhibition, Hardtmuth carbons will be largely used for the arc lamps.

Traction by Accumulators.—In our issue of the 23rd ult., under the heading "The Brussels Tramways," we noticed the unsuccessful results obtained with the cars, worked by accumulators, on the tramway between the Rue Belliard and the Place Royale, and subsequently on the tramway along the Rue de la Loi. The *Moniteur Industriel*, which has always been "dead against" the use of accumulators for traction, regarding it as the most complicated and costly means of applying electrical power for the purpose, considers that this failure affords conclusive evidence in support of the position it has taken up, and an absolute condemnation of the decision of the special jury at the Antwerp Exhibition to the effect that the system of working by accumulators is superior to all others—a decision which it characterises as *idiotic*. Our contemporary holds, moreover, that, up to the present time, the accumulators which

have been employed for traction may indifferently be regarded as "not good for much," though it admits that a type of accumulators susceptible of being economically worked may some day be forthcoming. From the report of the Brussels Tramway Co. it appears that the use of electricity during last year resulted in a loss, for the three cars which have been referred to, of 15,876 francs, or of 5,292f. per car, and that the maintenance of the accumulators, after deducting general expenses, amounted to 22 centimes per car-kilometer, *i.e.*, to more than the cost of animal traction inclusive of general expenses. The conditions of working on the tramway along the Rue de la Loi, which is in a straight line and almost level, are considered as exceptionally favourable. Before endorsing the conclusions of our contemporary we should require some comparative data as to the particular type of accumulator employed on the Brussels tramways, and as to the system employed in charging and working it.

Hamburg.—The town electric works offer to supply private consumers with current available from 12 noon to sunrise the next morning, on the following conditions. Connections will be made and kept up by the works at the expense of the consumer at rates to be determined each year by the authorities. The meters are to be supplied by the works, and may be bought or hired by the consumer; so will glow and arc lamps and carbons be kept in stock. Lamps procured by the consumer elsewhere must correspond in type to the current supplied. Repairs in hired meters fall on the works; in bought meters, on the consumer. Small repairs in wires, lamps, &c., supplied by the works, not to be charged. Notice must at once be given of anything wrong. If heating sets in, the current must be cut off, and only restored under direction of the management. The meter will be read weekly as a rule, but never seldomer than once a month. The rate for current will be by meter 4pf. per 50 volt ampere-hour (9·6d. per Board of Trade unit); which corresponds to about $\frac{1}{25}$ shilling per 16-candle glow lamp per hour; or to $\frac{6}{25}$ shilling per 600-candle arc lamp per hour. Odd numbers of arc lamps to be charged as the next even number. The consumer, also, will pay 5s. per glow lamp, 10s. per arc lamp per annum; this will become 2s. 6d. and 5s. respectively if the consumer uses all his lamps an average of $2\frac{1}{2}$ hours each; and will be reduced to nothing if the consumer has a daily average of 3 hours per lamp. The town reserves the right to revise the prices at the end of each year, and at any time to entertain applications for electricity for any other purposes than lighting, and to sell the same at any other price than that charged for lighting. No credits beyond eight days—otherwise, "cut off." Security for the cost must be given before the current will be introduced. The supply may also be cut off if access be denied to any room in which wires are laid. Notice is to be given of the intention to cease using the current; if this be not done, the consumer will continue liable for the meter rent.

A Pillar of Light at Sea.—According to a "Seafarer," writing in the *Daily Telegraph*, the master of a Spanish steamer that lately arrived at an English port from the east coast of South America, has given particulars of a very interesting luminous appearance, probably electrical, that was encountered by him about 100 miles south of the equator. He was in his cabin, he says, when he was awakened by his chief officer, who begged him to step on deck at once to view and pronounce upon a singular light, towards which the steamer was directly heading. The mate added that he had slowed the engines down, as he did not like the idea of running into that strange shining on his own responsibility. The captain mounted to the bridge, and looking ahead, witnessed a very extraordinary sight. The sea was calm, with a light swell rolling from the east; the time was shortly after midnight; the sky was dark and starless, yet the dusk was clear—that is to say, a ship's lights, for example, would have been visible for a considerable distance. Right on a line with the bows of the steamer there stood, or seemed to stand, a vast shaft of pale-greenish light, apparently about three-quarters of a mile broad, and, owing to the nearness of the vessel to it, seemingly elevated to the height of about forty-five degrees. Its outline was defined with singular clearness upon the blackness that was on either hand of it, and above and into whose folds there entered, doubtless from contrast, a deeper dye of gloom. There was no distortion whatever, no curvature in the oblong form of the luminous appearance. It was reared like some substantial object that had been coated with phosphorous. The Spanish captain collecting, after a brief glance, the character of the space of brightness, signalled to the engine-room to go full speed ahead, and presently the ship steamed into the glittering volume. It was noticeable that although, when quite close to the body, the vessel continued in blackness, proving, at least, to the satisfaction of the Spanish captain, that the light possessed no powers of externally illuminating; the moment the ship had driven into the thick of it everything was as plain aboard her as though she had been bathed in soft waning moonlight. The ship occupied about seven minutes in steaming through this shaft of light; she then emerged into the blackness of the night again, leaving the radiance shining very clearly over her stern, where it gradually narrowed and grew dimmer as it receded, until it died out in the distance.

Philadelphia.—The Edison Electric Light Company of this city are erecting the largest station for lighting in this country. As this station is to supply the central portion of the city, the land on which it is built is very valuable; it was, therefore, necessary to limit the area to 70ft. by 100ft. In order to get the required space, the building is carried up 114ft. above the pavement, and is divided into six storeys. On the ground floor will be located 20 engines of 250 I.-H.-P. each. They are of the Armington-Sims type, running at 200 revolutions per minute. The foundation for the engines will be practically solid with the concrete foundation of the building. On the second floor will be forty dynamos of 1,500 lights each, making the total capacity of the station 60,000 16 c.-p. lamps. The dynamos will weigh about 7 tons each, and will run at a speed of 650 revolutions per minute. On the third floor will be the workshops, where wires and conduits are prepared for laying in the streets and making connections with houses. On this floor will also be located the two blast fans, driving 50,000 cubic feet of air per minute into the furnaces. The products of combustion will be discharged by means of two shafts, 9ft. in diameter, and so built on either side of the house as to resemble huge bow windows starting from the third floor. On the fourth floor will be placed the boilers. Their rated capacity is 5,000 h.-p., and they are to be of the Abendroth and Root tubular pattern. The smoke will be discharged downwards into the flues on the third floor, and the ashes, which will fall into pyramidal ash pans, will be discharged into cans on the same floor. On the fifth floor there is storage capacity for 1,000 tons of coal. The arrangements are such that on the first

floor the coal waggons are driven on to scales. After being weighed the coal is discharged into shoots, delivering directly into elevators, which carry it to the fifth floor, where it is shot into the bins. Arrangements are made for delivering the coal directly in front of each boiler. On the sixth or top floor will be the general offices of the company. The distribution is to be on the three wire system, and there are thirty-five mains leading out of this station. The company has already expended £40,000 for copper conductors, and eleven miles of street mains have been laid, leaving about twenty miles more to cover the district. This quantity will be laid during the coming summer. The station when finished will cost £200,000. Arrangements have already been entered into to furnish upwards of 10,000 lamps, and as the company intends furnishing power in any quantity that may be desired up to 100 h.-p., there is no doubt but that the venture will be a financial success.—*Industries.*

Weston-super-Mare.—It will be remembered that some experimental lighting has been carried out at Weston, but the powers that were did not view the proposal of a permanent installation with favour. The future of electric lighting, however, seems favourable in that some of the candidates at the Local Board election have thought necessary to mention the subject of the light in their addresses. Thus the Rev. W. Boyden said :—" In reference to one matter he was at issue with a large number of the members of the present Board—he meant the electric lighting of the town. He was very sorry the Town Commissioners thought it to be their duty to ignore the wishes of a public meeting—a large and influential meeting—and to set at nought the opinions of all the medical men of the town, and to snuff it out. He thought they were treated with scant courtesy. Now, that was one of the things in his estimation which might have rendered the town increasingly attractive, and have had a tendency to draw thousands of visitors to it during the coming season. He believed that one objector to electric light on the Board said that it was in its infancy ; nevertheless, infancy is the period of interest. When electric light had lost its novelty, and everybody had adopted it, it would be of precious little use introduced into Weston as an attraction to outsiders. Now was the time when it might have been applied to advantage. He knew it was not altogether thrown out of court, as there was an intimation that the Commissioners might do something on their own account, but he owned it would have been much better to have accepted the contract with the proviso. Perhaps if the Board went in for an experiment it might turn out like the experiment for the ventilation of the sewers, which was costly and unsatisfactory. Then the cost of the electric light was not very serious ; it was placed before them in the press. He should have been much more pleased to have seen a system introduced, and to have saved something which appeared to him to be wastefully expended at the present moment." On the other hand, Mr. Jesse Shorney, an old member of the local board, said, with regard to the electric light, he should be pleased to see it introduced into Weston-super Mare, if it could be done with the money the board had at their disposal. The lighting the sea front by electricity would add another twopence to the rates, and to light the whole town would necessitate an increase of from 4d. to 5d. in the pound, hence he thought it was wise to postpone the question for twelve months, during which time something better, if not cheaper, might come up. When we see electric lighting made thus prominent in local elections, matters must be progressing.

Lighting the Suez Canal.—The *Times* of March 20, in an article on this subject, says a scheme has been formulated, having a twofold character, which is now being carried into practical effect. Firstly, the canal itself is to be lighted, throughout its entire length, with such lights as will enable vessels to keep their proper course with certainty ; and, secondly, all ships navigating the canal by night are to be provided with such a system of electric lighting as shall meet the approval of the Company. The latter has been carried into effect—as is well known—before the former. At one time, also, there were rumours that the canal was to be electrically lighted throughout, and that transformers would be used. It seems, however, that compressed gas is to be used, and that to a large extent. The Pintsch's system of such lighting will be followed. After having described the canal lighting, the *Times* says :—" Having described the arrangements for illuminating the waterway of the Canal, we will now turn to the equipment of the ships which will traverse it by night, and the conditions under which they will be permitted to avail themselves of this privilege. Steamers will be allowed by the regulations for the night passage to proceed under the same conditions as those laid down for the traffic by day, but with certain additional arrangements. In the first place, they must show to the satisfaction of the officials of the Canal Company, either at Port Said or at Port Tewfik, that they are provided with an electric projection at the stem or fore part of the vessel capable of throwing a light for 1,200 metres. They must also have an electric light, with a shade suspended over the deck, and capable of illuminating a circular field about 200 metres in diameter. The company's officials will decide whether or not the apparatus carried fulfils the required conditions, and whether or not it affords a sufficient guarantee for the steamer carrying it to be safely authorised to proceed through the canal by night. If in navigating by night a steamer receives an order to go into a siding, she must immediately on obeying the order extinguish all her electric lights and show only the regular signal lights of a vessel lying at a siding during the night, namely, a white light at stem and stern and a watch or anchor light. When two or more steamers provided with the necessary electric light are passing through the Canal by night in the same direction, if one of them is stopped she must immediately hoist a red light at the mizen masthead and give three short quick blasts with her whistle, which must be repeated at intervals of a few seconds until the steamer following acknowledges her signal by repeating it. These signals require the immediate slackening of speed, to enable the vessel to stop should it be necessary. The dredgers of the company, when at work, are to be guided by special instructions, and to be signalled by means of a whistle. They are also required to extinguish all electric lights when lying at the sidings. The lights to be used at the stations for signalling to passing steamers are of three kinds. To slacken speed three white lights, one above the other, will be employed ; to go into the siding two white lights, one above the other, will be shown ; and to pass one white light only will be exhibited. When these signals are addressed to a vessel coming from the north, a fixed red light will be placed above the white lights. When, on the contrary, they are addressed to a vessel coming from the south, the red light will be placed under the white lights."

SOME POINTS IN THE MECHANICAL CONSTRUCTION OF DYNAMOS.*

Some time ago we published, under this heading, an article in which we drew attention to the necessity of constructing dynamos, not only with regard to electrical, but also with regard to mechanical requirements; and we dwelt more especially upon the importance of supporting the armature core in a substantial manner, and employing a spindle of ample size and suitable shape. Dynamo makers sometimes neglect these points; and a machine which is electrically and magnetically all that could be desired fails from some purely mechanical defect which, with a little forethought, could easily have been avoided. Let any of our readers examine half a dozen dynamos of the same classified output, and as nearly as possible of the same speed, but by different makers, and he will speedily come to the conclusion that there is no system whatever as regards the dimensions of the working parts. Whilst one maker employs bearings six diameters long, another is content with four diameters; in one machine the bearing next to the pulley is of the same size as that next to the commutator, and in another machine the latter is smaller, and discrepancies of 20 to 30 per cent. in the sizes of spindles are by no means uncommon. It is, of course, not always possible to dimension working parts to the fraction of an inch; existing patterns have to be used in, and it will often pay to make a spindle stouter or a bearing longer than necessary in order to avoid too great a multiplication of standard sizes, and so reduce shop expenses. The variations which occur in similar machines of different makers are, however, far too great to be accounted for by such reasons, and the true explanation will probably be found in the fact that electrical engineering has not yet shaken itself into generally accepted grooves, and each maker goes his way without troubling himself much about the mechanical strength of his machines until a breakdown occurs, which reminds him that this or that part is too weak. Then the particular part is increased in all the machines, and so the process of evolution goes on producing the heterogenous result above alluded to. In other branches of engineering there is much greater uniformity of sizes. If we inspect half a dozen portable engines of the best makers, we shall find almost identical dimensions of cylinder, piston rod, cross head pin, crank pin, crank shaft, bearings, &c., and even the grate and heating surfaces will be found the same within a few per cent. But then portable engine making is a much older trade than dynamo making, and with time the anomalies and vagaries of design in the younger trade will no doubt also vanish.

One of these anomalies which deserves special mention is the size of dynamo pulleys. The size of a belt and corresponding pulley to transmit a given power at a certain speed can be calculated to a nicity, and even an ordinary millwright would never dream of putting a pulley on a shaft without having first ascertained, either from previous experience or from calculation, what size to make it so that the requisite power can be safely transmitted. We doubt whether the highly scientific dynamo maker does the same. He puts on a pulley which he thinks will "about do," and if the machines gets on the job, and it is found that with the original pulley the required speed cannot be obtained, the remedy is simply the putting on of a smaller pulley regardless of the possible dangers of overstrained belts, bent spindles or hot bearings. For the benefit of our younger readers we shall in this article discuss the question of dynamo pulleys, so that they may learn how to avoid such mistakes.

The power which can be safely transmitted by a belt depends on the permissible working stress in the belt, its speed, the coefficient of friction between belt and pulley, and the arc spanned by the belt. The pull transmitted is the difference in the stress between the driving and slack side of the belt. Let T_1 represent the former and T_2 the latter in lb., then the pull P at the circumference of the pulley is

$$P = T_1 - T_2.$$

* See page 78 (Jan. 27) for previous article on this subject.

At a belt speed of s feet per minute the transmitted power is

$$\text{H.-P.} = \frac{(T_1 - T_2)s}{33{,}000}.$$

The belt speed with a pulley d inches in diameter and running at n revolutions per minute is

$$s = \frac{\pi d}{12} n.$$

If, therefore, we know the size of pulley, the revolutions per minute and the horse-power, we can calculate the pull transmitted, and to find the dimensions of the belt, we must determine the relation between this pull and the working stresses in the two sides of the belt. Let f be the co-efficient of friction between belt and pulley and α the ratio of the arc spanned by the pulley to its circumference, then the ratio τ between the working stresses in the tight and slack side of the belt is

$$\tau = \frac{T_1}{T_2} = e^{2\pi f \alpha}$$

where $e = 2{\cdot}71828$, the base of Naperian logarithms. It will not be necessary in this place to demonstrate the above formulæ for τ, as it can be found in any text book on applied mechanics.

Our object is to show how the sizes of belts and pulleys for any given dynamo can be calculated, and for practical use we append a table by means of which the size of pulley and width and thickness of belt for any power can be found almost at a glance, but in reducing the problem to this very simple form it is of course necessary to sacrifice the general applicability of the formulæ by assuming certain conditions which should as far as possible represent the majority of cases arising in practice. These conditions are —1st, the arc spanned by the belt; 2nd, the co-efficient of friction; and, 3rd, the safe working load per square inch of belt section.

As regards the first condition it should be borne in mind that dynamos are generally speeded faster than the machines to which they are belted. The pulley on the dynamo is therefore smaller than the rigger on the counter-shaft or the fly-wheel of the engine from which it is driven, and the arc spanned by the belt on the dynamo pulley must be less than π (180 deg.). How much less will depend on the distance of centres and the dimensions of the pulleys; also on the position of the tight side of the belt. If the tight side in a horizontal transmission is above, and the slack side below, the arc spanned will be less than with the opposite arrangement, and to get a maximum of "grip" with a minimum of strain in the belt and on the dynamo spindle the dynamo should be put down in such way that the slack side of the belt comes uppermost, In this case, even with very short centres, the arc spanned on the dynamo pulley will be greater than $0{\cdot}4 \times 2\pi$, but in order to include cases where local conditions render this arrangement impracticable, we shall assume that $\alpha = 0{\cdot}4$, that is to say, that the belt spans forty per cent of the total circumference of the pulley.

The next point to settle is the co-efficient of friction f; and here we are met by the difficulty that the authorities widely disagree. We find from Rankine's Mechanical Text Book that the co-efficient between leather and metals varies from ·15 to ·56, according to the condition of the surfaces and lubrication; and in his Rules and Tables, page 241, he recommends that calculations of driving-belts should be made on the supposition that the surfaces are oily, when it will not be safe to assume more than ·15 for the co-efficient of friction. In his "Machinery and Millwork," page 352, we find, however, that, in view of the experiments of Messrs. Towne and Briggs, the author rejects Reuleaux's co-efficiency of ·25, and recommends ·42 as safe in all cases where reasonable care is taken to keep the belts dry. Weisbach gives $f = {\cdot}28$ for turned cast-iron pulleys with a polished and greasy surface; and Unwin, in his "Elements of Machine Design," page 311, recommends for ordinary cases a co-efficient lying between ·3 and ·4 Where authorities differ to such an extent, the practical engineer is left very much to his own judgment as to which of the values of f he will adopt in his general practice. The writer from his own experience has found that a co-efficient of ·3 is safe, and this value will therefore be taken in the following calculation :—

Having settled the length of arc spanned and the co-

it of friction we can determine the ratio between the s in the tight and slack side of the belt when at work.

$$\tau = e^{2\pi . 0\cdot 12} = 2\cdot 125.$$

ress in the tight side is therefore a little more than that in the slack side, and the pull transmitted is

$$P = \cdot 53\ T_1.$$

we can find the section of belt required to stand the T_1, we have yet to settle the third of the conditions oned above, viz., the safe working load. Here again d considerable variance in the figures given in text Morin recommends a working load of ·2 kilos. uare millimeter, or say 285lb. per square inch; the ook of the German Engineers' Society "Hütte" mends ·1 to ·125 kilos., or say 175lb. per square Leloutre (Résumé de la Societé des Ingenieurs December, 1878, page 315), recommends a working s high as 700lb. per square inch (on the ground that r strained to this point is not liable to stretch any , whilst Unwin fixes the working load at 320lb. accepting any one of these widely different figures be useful to inquire what regulates the acceptance of rticular working load. This must evidently depend ultimate breaking strength of the belt and the factor ty we may choose to employ. The ultimate strength leather used for belting varies, according to Unwin, n 3,000lb. and 5,000lb.; whilst Rankine gives it as b. for the solid parts of the belt, and 2,400lb. for the l joint. The laced joints will break when the load s 1,300lb. per square inch of the solid part. Now, as dynamo-driving is concerned, laced joints may be ered a thing of the past. They are objectionable not ecause of their weakness, but also because the joint sing over the dynamo pulley produces sometimes a jerk in the movement of the armature, and a corre- ng flicker in the lights. The great convenience of joints is that the belt can easily be tightened it has become slack from stretching, but as dynamos ays are nearly always provided with sliding bed and ing gear, a cemented or riveted belt is equally con- t. This consideration also disposes of M. Leloutre's ent regarding the loading of belts beyond the stretch- int above mentioned. In determining the size of a e must, obviously, base our calculations on the strength riveted joint, that is, take 2,400 as the breaking but even this figure is too high, because it was deter- with a steadily increasing load, whereas, in actual every part of the belt is subjected to continual varia- f strain as it passes from the tight to the slack side, ck again to the tight side. These variations occur times per minute, and it is well known that all als become fatigued under varying strains, and break smaller ultimate load than would have been the case he load been constant. According to Leloutre reaking stress of belts is 4,300 lbs. with a nt, and 2,800lb. with a variable load. The fatigue s therefore the ultimate load to 65 per cent. of its l value, and applying this to riveted joints we can alculate their ultimate strength as 1,560lb. With a of safety equal to 4½lb. this corresponds to a working f 350lb., and with a factor of 5 to a working load of

Since the strain resulting from bending (and which ve neglected in the above calculation) is somewhat r for double belts than for single belts, we adopt a of 5 for the former and 4½ for the latter, so that the sectional area for double belts (from $\frac{5}{16}$in. to $\frac{3}{8}$in. must be calculated for a working load of 310lb. per inch, and that for single belts ($\frac{3}{16}$in. to $\frac{3}{8}$in. thick) vorking load of 350lb. per square inch.

he above formula giving the relation betwe n the g strain in the driving side of the belt and the pull itted to the pulley, no account has been taken of the ce of centrifugal force. In slow-speed machinery ctor is trifling, but with high-speed machines, such as os, it may sometimes become necessary to take cen- l force into account. The effect of this force is a cy to lift each particle of belt, as it travels round the , off its surface, and thus to diminish the grip and the ansmissible with a given working stress. To coun- this tendency, it is necessary to put the belt on tighter to begin with; and this must obviously increase T_1 as compared with the stress which would suffice did centrifugal force not interfere. It would be outside the scope of this article, which aims at giving a few simple data for practical use, were we to investigate mathematically all the conditions under which the belt works; it must therefore suffice to state without giving the mathematical proof that the increase of stress occasioned by centrifugal force can be found as follows. Imagine a piece of the belt, of length equal to the radius of the pulley, cut off and weighed. Let this weight, W, be concentrated in one point at the circumference of the pulley, and find the corresponding centrifugal force by the formula

$$F = \cdot 000344\ W \frac{d}{2} n^2,$$

then F represents the force in lbs. which must be added to the theoretical load T_1 to obtain the total working stress in the driving side of the belt. To estimate the importance or otherwise of this correction we shall take as an example the case of a 12in. pulley running at 1,000 revolutions with an 8in. belt ¼in. thick. The specific gravity of leather is very nearly that of water, and is generally taken as 60lb. per cubic foot. A piece of this belt 6in. long will therefore weigh ·83lb. The centrifugal force is

$$F = \cdot 000344 \times 0\cdot 83 \times 0\cdot 5 \times 1000^2 = 143\text{lb.},$$

which, distributed over a belt area of 4 square inches, increases the theoretical load by only 36lb., or less than 12 per cent of the working load. Now it is evident that we must allow some margin in the tightness with which the belt is originally put on, for the simple reason that this work must be left to the judgment or mechanical instinct of the attendant, and as it will hardly be safe to allow a smaller margin than 25 per cent. on this account, ample allowance is thereby also made for the influence of centrifugal force. In our previous article it was pointed out that a dynamo, to be mechanically perfect, must be able to stand an occasional short circuit, but only for a very short time. Now, where the dynamo is driven from its own engine, a short circuit will pull the engine up before the excessive current has had time to dangerously heat the machine; but where the dynamo is driven by belt from a main shaft, which may be receiving motion from a large engine the power of which is much in excess of that of the dynamo, a short circuit will not pull the engine up; and to save the dynamo from overheating it is very desirable that in such a case the belt should come off. For this reason the margin of belt-power should not be too great, and in the following table we have adopted 25 per cent. as a sufficient allowance for injudicious tightening, whilst at the same time the allowance is sufficiently small to cause the belt to break or to fly oft if the machine be short-circuited :—

PULLEYS FOR DYNAMO MACHINES.

Diam. inches.	Wdth of Belt.		Area. Square in.	Working Stress lb.	Trnsmittal Pull lb.	Horsepwer* at 1,000 Rev.
	¼in thk	½in thk				
6	4	—	1·00	350	140	6·5
7	5	—	1·25	437	175	10
8	6	—	1·50	525	210	13·5
8	—	4	2·00	620	248	16
9	7	—	1.75	613	245	17·5
9	—	5	2·50	775	310	22
10	8	—	2·00	700	280	22
10	—	6	3·00	930	372	29·5
12	—	7	3·50	1,081	433	41·5
15	—	8	4 00	1,240	496	59
18	—	10	5·00	1,550	620	88
24	—	12	6·00	1,860	742	141
30	—	14	7·00	2,170	865	205

*The horse-powers are given to nearest decimal.

The use of this table will best be explained by one or two examples. Say we have a dynamo running at 1,500 revolutions and absorbing 20 h.-p. What pulley and belt will be required? Reduce power in accordance with speed from 20 to $20 . \frac{1,000}{1,500} = 13\cdot 4$. The nearest number in the horse-power column occurs in the third line, viz., 13·5, and the corresponding pulley is 8in. diameter, and

should be about 7in. wide to take a 6in. single belt, ¼in. thick. If the belt is of a different thickness, the width may be altered so as to keep the cross-sectional area 1·5 square inches, as given in the table. Should a different diameter of pulley be desirable, the area of belt must be changed inversely. As a second example, assume that we want to know the pulley to be used with a dynamo absorbing 60 h.-p., and running at 400 revolutions. Increase power in accordance with speed from 60 to $60 . \frac{1,000}{400} = 150$ h.-p., and find the nearest number in the table, which is 141. The pulley will be 24in. in diameter, and the belt $12 . \frac{150}{141} = 12{\cdot}8$, or say 13in. wide, if its thickness be half an inch. The table can also be used to find the power which can be transmitted with any given pulley and belt, but as these applications are obvious, we need not describe them at length.

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

(Continued from page 222.)

16. *Electrical Return.*—In estimating the energy actually returned at the terminals of the dynamos at 70 per cent. of the horse-power indicated in the cylinders, it is assumed that the engine drives on to countershafting from which the several dynamos are driven. In the Victoria Station installation, when tested some years ago, it was found that 65 per cent. of the I.-H.-P. was returned at the terminals. But since then considerable improvements have been made, not only in the dynamos themselves, but in the methods of laying down large installations. In July, 1886, there were published in *Industries* the results of several determinations made by Messrs. Paterson and Cooper, on their machines driven by Gwynne's engines, and the mean of the experiments showed that 71·3 per cent. of the I.-H.-P. was returned at the machine terminals in the form of electrical energy. Later, in the same year, the results obtained by Dr. Hopkinson in testing the Tilbury Docks installation were published in *The Electrician*. This installation was erected by Messrs. Crompton, and there was obtained in the circuits a useful return of from 70 to 72 per cent. of the I.-H.-P. It is most probable that the eighteen months which have elapsed since then have brought us a still higher return.

The above results apply to cases in which the dynamos are driven through countershafting, and the work expended in overcoming the friction of countershafting is very considerable. When the employment of the latter is indispensible the engines and dynamos ought if possible to be on opposite sides of the shaft, in which case the pressure on the bearings becomes very much smaller than when both engines and dynamos are on the same side. But unfortunately the arrangement is generally the other way, and when countershafting is used it absorbs in consequence a large percentage of the total power. The direct belting of the dynamos to the engines has considerable advantages, and this method may be expected to come largely into use in time. Instead of driving a number of dynamos from one large engine the tendency is to divide up the power, driving only one or two machines from smaller engines. When two are driven a flywheel pulley is keyed on each end of the crank shaft, a machine being belted from each. Though the percentage obtained with directly belted dynamos is necessarily higher than with those driven through countershafting, the writer is not aware that any experiments have been published showing the return actually obtained.

It is still an open question whether better results are obtained with dynamos directly coupled to the engine crank shaft or with those directly belted. The directly driven machine must have a low speed, which, as regards efficiency, is bad in a dynamo; while the engine must have a high speed, bad *per se* in an engine. It seems that the best proportion between the speeds of prime mover and dynamo is obtained by the directly belted combination, though one is bound to confess that the chief objection to the directly coupled arrangement lies in the high price required for the dynamo, in order that for such low speed as is compatible with engine durability its efficiency may be as high as a belted machine. There is a great number of directly coupled machines at work giving great satisfaction to the users, and they possess the advantage of taking up less room than when belt driving is adopted. As regards the return obtained there are no reliable data. A set of tests on a combination of Willans engine and Crompton dynamo belonging to the Vienna installation was published in April, 1886; but the tests were not conducted properly, and both I.-H.-P. and electrical horse-power varied during the trial run in a very extraordinary way. The tabulated results showed a return of from 66·5 to 79·8 per cent. Probably the true value lies between the two at 74 per cent., but it is hard to say. In a paper read at the Institution of Civil Engineers three weeks ago Mr. Willans claims to have obtained at his dynamo terminals the high return of 82·3 per cent. of the I.-H.-P. The detailed figures of the test have not yet been published.

17. *Dynamo and Engine Trials.*—In making tests of the kind above described the fulfilment of several conditions is important if trustworthy results are to be obtained. In the first place the electrical load must be constant during the whole time of the trial. In the absence of the lamps the circuit may consist of large resistance frames, or better still of a water resistance, which is very easy to manage. In the latter the plates forming the electrodes are movable, and can be adjusted to any distance apart. The engine should be run with the stop valve full open, the period of admission, &c., being regulated by the expansion gear. If it is only desired to establish the relation between the energy obtained from the dynamos and the I.-H.-P., simultaneous indications of the engine and observations of the measuring instruments are all that are required, and the duration of the trial need not exceed the time required to take half a-dozen sets of readings. Diagrams from the two ends of the cylinder necessarily take some time to draw, and it is absolutely essential that during the time so occupied, the speeds remain constant. It is very easy to fulfil this condition if the load is constant and everything in fine running order; in fact there is no reason, under such circumstances, for any variation in speed. Speed indicators, attached to both dynamos and engines, should be watched while the diagrams are being taken. If, due to any cause, variations occur, that set of readings should be cancelled. The speed indicators should, of course, be carefully checked by counters.

When a test run has to be made for the purpose of ascertaining the efficiency of the boilers and engines, it should extend over several hours, and the same conditions must be observed regarding constancy of load during the trial. The cost of electric lighting depends to a great extent on the amount of fuel consumed, and this is determined by the efficiencies of the boilers and engines, the former estimated according to the weight of water evaporated per pound of fuel consumed, and the latter by the I.-H.-P. which can be maintained for a certain weight of steam used per hour, and by the ratio of the power delivered at the crank shaft to that indicated in the cylinders. The efficiency of the whole system thus depends on the electrical power obtained at one end of a series of energy transformations for the coal and water furnished at the other end. In starting a plant for the first time it is necessary to have a good preliminary run before the actual trial commences, not only for the purpose of getting the machinery into proper working trim, but in order that the whole of the operations may be properly equilibrated. It is necessary that there be supplied to the boiler just coal and water enough to give the required electrical power—no more, no less—and it is only by actual trial that these can be determined. It is fatal to the success of the trial to work by fits and starts, and results obtained under such conditions are quite untrustworthy. If the trial were run without preliminary adjustment and the boilers turned out to be rather large for their work, probably for half the run part of the steam would be blowing into the air through the safety valves. On the other hand, if the boilers were too small the steam would go down, disturbing the equilibrium of the system, and assuming the possibility of getting the steam up again this could only be realised by hard and consequently wasteful firing. In the latter case the electrical load must be reduced until the steaming capacity of

lers is reached, when the trial run can proceed with hing in perfect balance. With some of the rapid tion boilers now in use stoking becomes something e art, and not one stoker out of ten, unless used to boiler, can undertake the job of keeping the steam right pressure without allowing it to blow through eties, or the water to rise or fall in his gauge glass. okers have a good deal in their power, and can lly make the coal bill high or low. Having ascer- the exact amount of fuel and feed water required to in the engines at uniform speed with the load fixed he trial commences. While it continues the steam e must be kept uniform and the water supply d, so that throughout the run it stands at ne height in the gauge glass. It is preferable the trial be a continuation of the preliminary nce towards the end of the latter everything is in condition. The run must not be continued till the falls; but the fires must be in the same condition the measurements cease as when they were started. the run the coal must be weighed and the water ed. Indicator diagrams should be taken at intervals or ten minutes, and observations of the current, nce of potential, and speeds, simultaneously made operly tabulated. If the trial run takes place on a t day to the preliminary, it may be necessary to run hour or so before taking readings, in order that the c., may be got into normal working conditions. The ent in getting up steam, and the time it is possible the load after ceasing to add fresh fuel, should be separately.

trials may be objected to on the grounds that the ons here laid down never obtain in practice. It is rue that in practical working such care is the excep- ut there is no reason why it should be so. More- until the objector tells us how bad we are to make l, until he specifies exactly the degree of careless- e are to adopt in our work, we are justified in show- at carefulness can do, and in turning out the best possible.

(To be continued.)

CHELTENHAM.

have already referred, in our issues of the 16th and lt., to the work energetically initiated and pushed d by the Lighting Committee of the Taunton Town l, and by Mr. H. G. Massingham, the managing r of the local electric lighting Company. Recently a ttee from Cheltenham paid a visit of inspection to stallation carried out by the Company in question, abstract the report made:—Though maintained in nt order, the central station of the Taunton Company a somewhat confined space at the back of Mr. gham's premises. Originally it was designed only ply the light to his shop and to a few adjoining ; but it has gradually developed as the area of supply tended, and especially since the contract has been for lighting the public streets. The power is obtained wo semi-portable boilers, working to a pressure of per inch, and driving two horizontal 35 h.-p. engines, operate a long transverse shafting to which the os are attached. The dynamos are five in number, lison and the others of the Thomson-Houston pattern. achinery and plant has been laid down to Mr. Mas- m's order by Messrs. Laing, Wharton, and Down, of n, the English agents of the Thomson-Houston Com- on whose system the Taunton installation is carried oth arc and incandescent lamps are supplied, the latter ent solely through the medium of accumulators, the s running only in the evening when the arc lamps are l. The arc lamps are about 65 in number, 30 of rented by the Corporation, and the remainder by customers. The incandescent lamps number about nd are supplied through four sets of accumulators, et consisting of 50 cells, equal to the supply of as 16-candle lights for eight hours without re-charging. three dynamos usually running at one time, one s the public arc lights, a second the arc lamps rented by private users, and the third charges the accumulators. The two reserve dynamos relieve the others at the will of the engineer in charge, but in case of necessity the service could be carried on for some time by two, or even one, of the dynamos, and easily by one of the two engines. From the central station the visitors were conducted to an inspection of one of the sets of accumulators placed in an up-stairs room of Mr. Massingham's large premises, and then they passed into the street, and went over the area of the public lighting service. This comprises the principal part—almost the whole of the business portion—of the town, within a half-mile radius of the works. The lamps, as already stated, are thirty in number, and average 100 yards apart. They are placed on standards, about twenty-five feet high, the lower part, to a height of five feet, being of iron, and the upper part of wood. These standards, though not positively unsightly, have not had appearance much studied in their construction, their cost having only been £3 a-piece. The wires are usually carried overhead from lamp to lamp direct, the old iron gas standards, elongated for the purpose, being used as intermediate supports. This suggests, as is the fact, that in the streets lighted by electricity, the use of gas has been entirely discarded, and the confidence thus shown by the Corporation in the new illuminant has not, during the twenty months that have elapsed since its adoption, been for one moment misplaced. Along a considerable length of the streets the wires are run on posts over the roofs of the houses, and this—as regards appear-ance, at least in the daytime—is certainly the preferable plan. Only in a very short section are the wires taken underground, a method of conveying them which entails risk from faults of insulation to which electricians attribute the partial failure of the service at Leamington.

The committee afterwards visited two or three of the business premises lighted by electricity. The result was very satisfactory, the visitors being particularly struck by the efficient manner in which arc lamps had been utilised for interior lighting. In the street lighting the distance between the lamps varies from 80 to 150 yards, the stan-dards being placed, when practicable, at the junctions with side streets. At any point midway between two lamps it was found that moderately-sized print could be read. The Corporation are negotiating for a considerable extension of the public lighting, and the electric light will no doubt be ultimately employed in all the thoroughfares of the town.

THE UNION BANK OF LONDON.

The head offices of all the principal banks are gradually being fitted with the electric light. This illuminant is better adapted for such lighting than any other with which we are acquainted. Indeed, this must be true in all cases where large numbers of *employés* are congregated together in the usually not too well ventilated rooms of ordinary London buildings. The head office of the Union Bank in Prince's-street is a modern building, hence could from the first be fitted with what we must still call the new light. The fittings throughout have been carried out by Messrs. B. Verity and Sons, of King-street, Covent Garden, under the supervision and from the designs of Messrs. Drake and Gorham, who are acting as engineers on behalf of the board. A few days ago we visited this installation, the plant for which is fixed in the basement, and consists of two 9 h.-p. Otto engines, driving two Elwell-Parker latest invented B-type 12-unit dynamos. Fig. 1 (see next page) illustrates these engines, and we are informed that they have run admirably from the first till now.

The dynamos run at 750 revolutions, and are fitted with heavy flywheels, to prevent any flickering of the lights. An accumulator battery of 106 Elwell-Parker, of 23 L-type cells in glass boxes, is used in conjunction with the machines. This battery supplies a part of the current during the time when most lamps are on, and furnishes current after the engines stop running. Distributing switch-boards, fitted with Drake and Gorham's patent ring contact switches, are used for controlling the various branch and main circuits. The wiring is carried out with a number of small circuits so arranged that should any failure occur to half the

generating plant every alternate lamp only will be effected. This arrangement also enables all the fuses to be placed in the engine room where they are readily accessible. The fittings have been specially designed for office work, and every desk standard has both gas and incandescent lamps, the jets projecting on either side of the incandescent lamp, and forming a support for the shade. The total number of lamps fixed is 330, most of which are half-frosted, either at the cap or point end, to suit pendants or standards. This method of toning the brilliancy of the filament is more economical than lamps frosted completely,

shown in the left hand corner. The stairs lead to the a mulator loft.

Two of Messrs. Drake and Gorham's Excess Indica are fixed in connection with the batteries to give warı when the normal rate of discharge is reached, and ther also a special arrangement of cut-out for the night ser so that in the event of an excessive number of lights b used for cleaning purposes after the offices are closed circuit is broken, and can only be replaced when the num of lamps has been reduced to the normal. This i arranged that it is impossible for it to be wedged out

THE UNION BANK OF LONDON INSTALLATION.

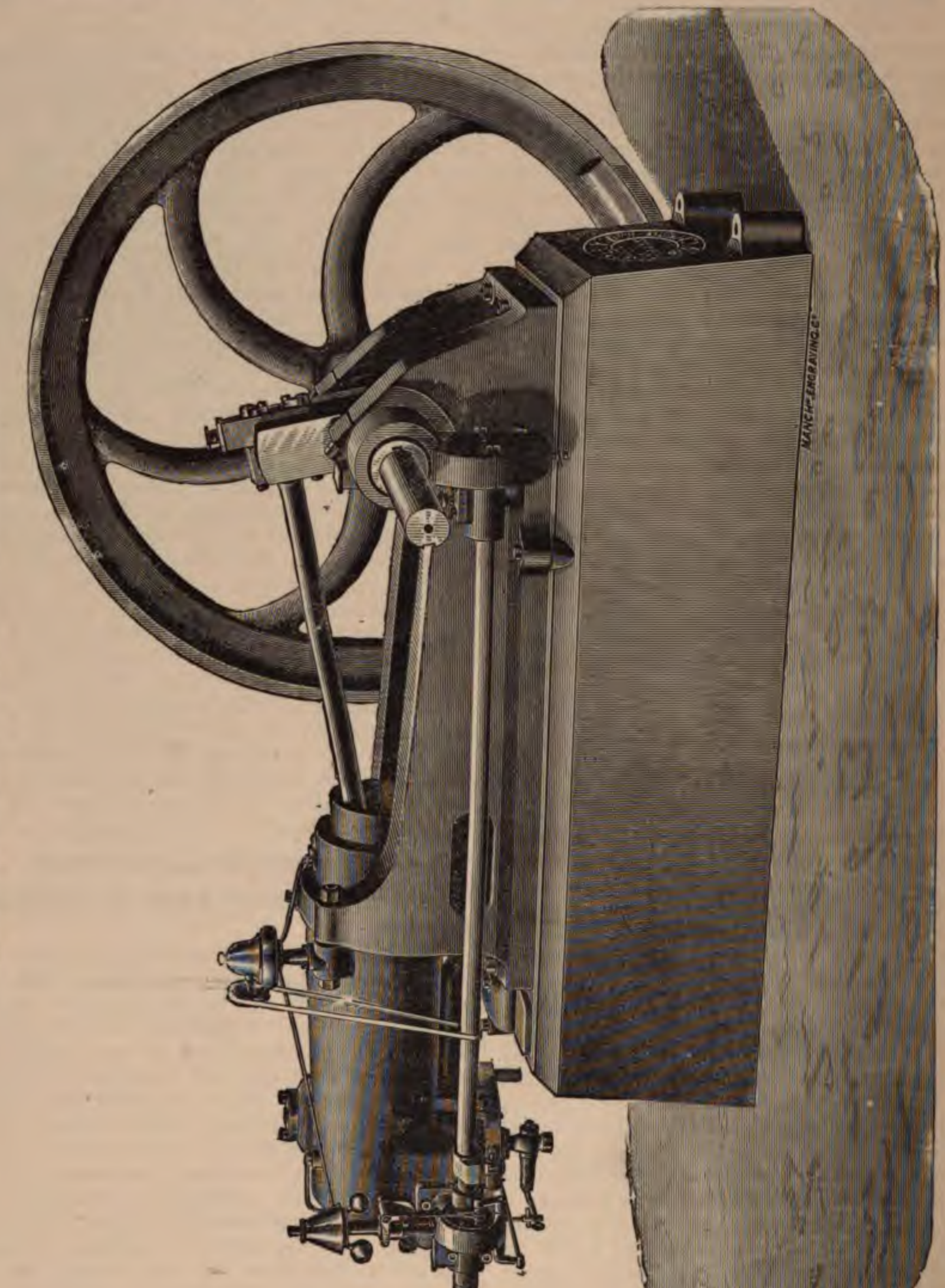


Fig. 1.—Nine Horse-Power "Otto" Gas Engine, by Crossley

as only the portion of the lamp in the line of the eye is obscured, the remainder reflecting its full light on the desks. A modified pattern of the Edison screw lamp holder with tap is employed throughout, and each lamp is provided with the well-known Edison pattern screw safety fuse. By means of terminal boards either dynamo can be connected to either battery, and the lighting circuits can be interchanged in a similar manner.

We illustrate on page 324 a plan of the arrangements in the engine room, except that we do not show the four water tanks. The terminal boards, instruments, &c., are

action, though at the same time it can be switched on aft it has worked. The designs for the silencing arrangemer in connection with the engines is found to answer admi ably, and there has not been the slightest complaint fr noise or vibration either from the bank officials or oth in the neighbourhood.

The ventilation of the engine room is effected by me of a Blackman air propeller, coupled direct to a one hor power Elwell-Parker motor, the speed of which can varied as required according to the temperature of room.

CORRESPONDENCE.

CATALOGUE PIRACY.

HE EDITOR OF THE ELECTRICAL ENGINEER.

lessrs. W. T. Glover and Co. call attention in issue to the copying of their catalogue by other nd suggest that some other parts of the same are not as original as they might be.

lowing may be one of the curious coincidences frequent enough in literature, or may illustrate ss of catalogue manufacture. It is a sample only.

N ELECTRIC CO. *ue (old), page 5.*	TELEGRAPH MFG. CO., LTD. *Catalogue, page 33.*
agnet cores are the best Norway oroughly annealed d as nearly as pos- presence of per- agnetism. agnets are wound having 96 to 99 of the conductivity opper.	Our cores are made of the best Swedish iron, thoroughly annealed, so as to avoid as nearly as possible the presence of permanent magnetism, and are wound with wire having 98 per cent. of the conductivity of pure copper.
ulate our own wire ost thorough man-	We insulate our own wire in the most careful manner, and finish the greater portion of our work by special machinery.
efer to use maho- the bases of our ts, for the reason kes a high polish, ially because it is liable of all the ods to warp or	We prefer to use teak in the bases of our instruments, for the reason that it takes a high polish, and especially because it is the least liable of all the fancy woods to warp or split; but we can use any other timber desired.

be remarked that the preference for teak does not d the preface. In the descriptions of the different ts it will be found that the bases are made of , as in the originals, the illustrations of which are fully reproduced. These originals account for the rt of pages 33 to 62, 74 to 79, 88 and 89.

ng attention to the above coincidences it should in e remembered, that it is a not unusual practice for make to supply blocks and descriptions for inser- e catalogues of those who do not make, but may ne of the above may be open to such an explanation, ot take up your space by discussing the ethics of on, but would simply remark that Messrs Glover considered somewhat unreasonable in complaining incere flattery as the complete imitation of their implies.—Yours, &c., J. E. KINGSBURY.

ril, 1888.

TELEPHONIC LITIGATION.

HE EDITOR OF THE ELECTRICAL ENGINEER.

s certain dealers in electro-magnetic telephones ng the newspaper reports of the recent case, "The elephone Company *v.* the Equitable Telephone n," as a means of pushing their business, pointing heir instruments employ no *carbon*, while it is the nsmitters of the Equitable Telephone Association eing specially attacked, it is well that the public informed that these said newspaper reports are se, as is frequent when the daily papers attempt scientific matters, calculated to give very erro- ressions.

atter of fact, the United Telephone Company are the receivers used by the Equitable Telephone n quite as much as the transmitter, and, if their can be upheld, all the "membrane" telephones e market are equally infringements.—Yours, &c.,

A. A. CAMPBELL SWINTON.

en Victoria-street, E.C., April 3.

FIRE OFFICE RULES.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR: It is whispered that the proposed new rules of the Society of Telegraph-Engineers and Electricians relating to electric light installations may not be materially different from those of the Phœnix Fire Office. If so, what good purpose can their promulgation serve?

Moreover, the Phœnix rules are *copyright*, and there may be something to say on that score presently.

Will anything be gained by attempting to establish a kind of dual control? On the contrary, will not the beneficial effect of the moral sway hitherto exerted be seriously weakened or altogether destroyed? There has been a certain safeguard to the public in the fact that contractors have generally evinced a readiness to conform to the Phœnix rules, and, as a natural consequence, the class of work has been steadily improving, and the "cutting" firms have been finding it increasingly difficult to oust the truly conscientious contractors. If users of the light discover that there is need (real or imaginary) of a rival set of regulations, the growing confidence in this branch of electrical engineering will be shaken. If there be any necessity for revision, or for extending the scope of the Phœnix rules, would it not have been possible to arrange a meeting of *representative electrical contractors* (upon whom the due execution of important works must fall, and not, I say it with all respect, upon the *consulting electricians*), at which Mr. Musgrave Heaphy, whose enthusiasm is admitted, and to whom belongs the credit of compiling the Phœnix rules and bringing them in successive editions to their now complete form, might be present, and conclusions arrived at satisfactory to all parties concerned?

It is to be hoped that the members of the profession will insist that an independent committee be appointed by the society to investigate and report upon the facts of this unfortunate dissension, and that such committee may invite Mr. Heaphy to give evidence and produce any correspondence that may have passed between himself and the Council of the Society on the subject, which is one of the utmost importance and merits careful investigation.

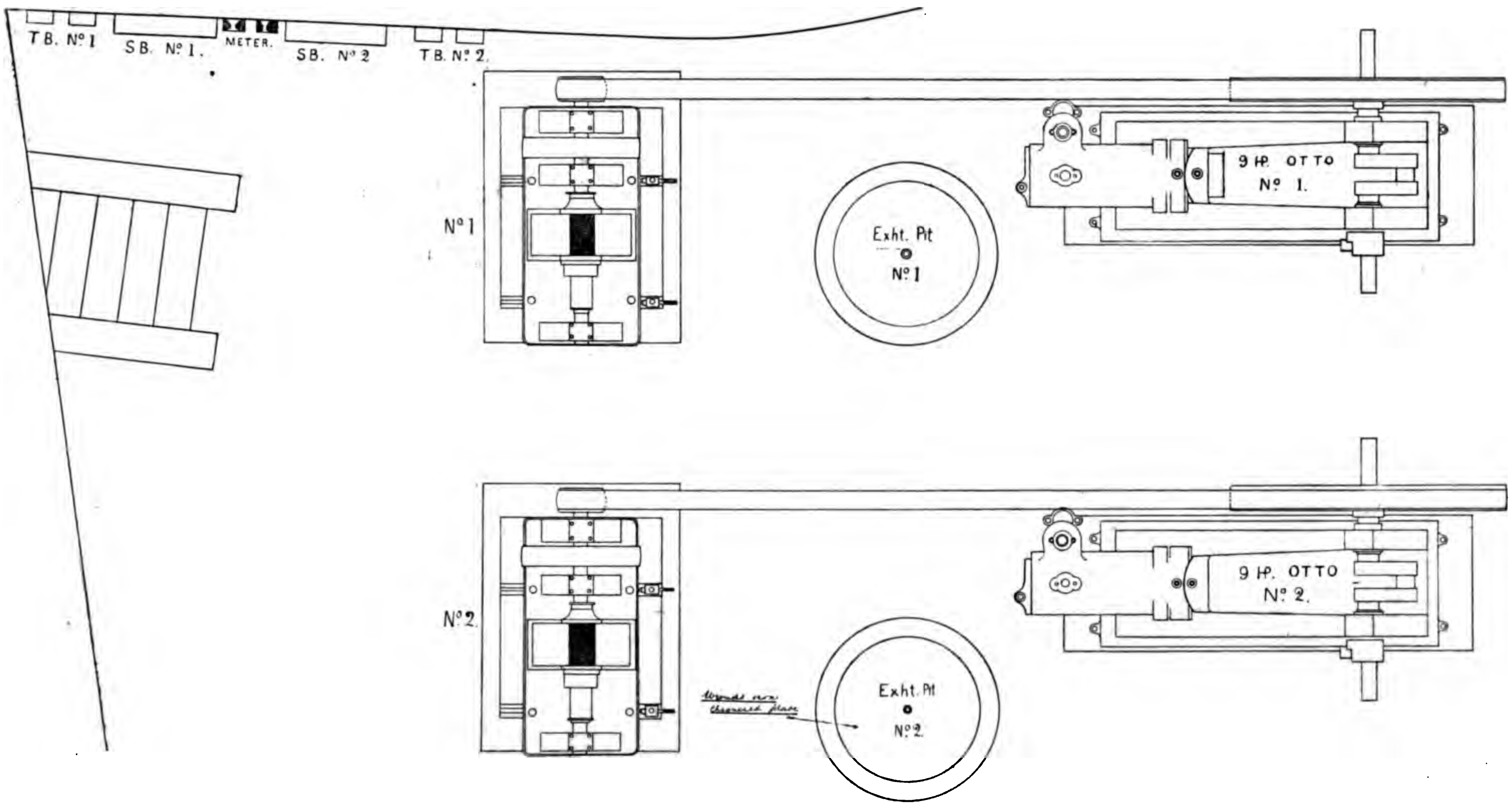
It is, perhaps, a question whether the council possesses the right to act in this matter without consulting the main body of members of the Society, and one thing is certain, viz., that scarcely a month will ever pass without the point involved being raised in some form or other, so that a settlement ought to be effected forthwith.

What we really need now is an efficient leader, and anyone possessing the requisite qualities who will come forward at this juncture will earn the lasting gratitude of the whole profession.—Yours, &c., CONTRACTOR.

Probably Electrical.—The following curious phenomenon, described by M. A. Lalance, would appear to require as the essential condition of its production a very dry atmosphere, such as that which sometimes prevails in Russia and Canada, a fact which points to the probability of an electrical causation. "On returning to my room on one occasion," says M. Lalance, "I found it full of thick black smoke. This smoke was due to two argand lamps which had been flaring. I opened one of the casements and went out for one hour, after which I was able to go to bed. Next morning I expected to find my papers and furniture in a terrible state, but to my great astonishment nothing was soiled. In the centre of the room, I observed on the carpet, a perfectly round ball from 3 to 4 centimetres in diameter, having the consistency of cigar ash. I found some other balls, but smaller and less perfect—that is to say, flattened to some extent at certain portions of the surface. In the angles of the room there was a small quantity of black dust. There was about 20deg. of frost outside, and the room was heated to about 20deg. centigrade." (This was in Russia: the temperatures in Fahrenheit degrees were about —4 and 68.) M. Lalance, who thinks that the phenomenon might be due to a difference of external and internal temperatures, and independent of absolute temperature, offers, in the *Journal du Ciel*, to supply any further particulars which might enable investigators to obtain a repetition of the phenomenon.

PLAN OF ENGINE ROOM.—UNION BANK INSTALLATION.

(*For details see page 321.*)



T B Nos. 1 and 2 show Terminal Boards; S B Nos. 1 and 2 show Switch Boards.
Exhaust Pits Nos. 1 and 2 [illegible] with wrought iron chequered plates; otherwise the plan explains itself.

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *who was in his scientific prime at the beginning of the century. This will be followed by* SIR HUMPHREY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

PROMOTERS' TACTICS.

The wisdom of the serpent, if not the harmlessness of the dove, dwelleth in those City offices devoted to the promotion of companies. Scarcely a week passes but our City Notes record the registration of one or more companies. And in due time these fledglings are sent out into the world to gather unto themselves many feathers in the shape of capital. It stands to reason that many of these companies are formed for quite legitimate objects, and yet the method of procedure in the promotion of such companies is often open to severe censure. One sentence reveals the real drift of the minds of the promoters, and it appears in almost every prospectus, to the effect that a quotation on the Stock Exchange will be asked for. Now the company that is really promoted for business purposes is altogether different from that promoted for speculative purposes, and both differ from the company where a substratum of business is intended to hide the real intention of Stock Exchange transactions. Our remarks are intended to apply solely and wholly to companies of an electrical character, manufacturing or distributing, and our grave objection to the tactics of the promoters is due to their care in so launching the company that the technical journals really conversant with the matters involved are unable to give a word of warning or a word of support. The prospectus is issued after these papers are gone to press in the one week, and the list is, if possible, closed before they go to press the next week. That is the rule, to which, however, there are a few exceptions. Such procedure immediately stamps the transaction as simply and purely speculative. It is the technically ignorant who are asked to subscribe, for, as we say, few of these prospectuses ever appear in the advertising columns of the technical paper. Testmonials —clear as noonday to the initiated—are used to influence those whose knowledge is confined to names, and not to scientific language or terms; and such persons are wholly unable to limit the purport of such documents to their intrinsic meaning. Frequently their real signification to investors is don't, don't, don't; and yet such testimonials form the principal paraphernalia of the promoter to induce subscription. Few things are as certain in electrical matters as that there is a screw loose somewhere in those undertakings which seek to avoid comment in the technical papers. Quite recently a large company has been floated, which is an offender in the direction we have already mentioned, and in others we are about to name. The patents bought and sold in this case have a certain small value, say, about one-twentieth of what has been paid, or is to be paid. The article is not an expensive one to manufacture, nor is it of great superiority to similar articles in the market. Put into the hands of a manufacturer, who would perhaps invest a few thousand pounds in pushing the

article, it would bring a fair but not an exorbitant return. As it is, the promoters no doubt hope to make a lot of money by selling foreign patents, hence they ask for thousands where tens would be amply sufficient. The whole affair is a gigantic gamble, and game of brag. The subscription is not derived from men who care one iota about business—their whole concern is quotation on the Stock Exchange. A market is somehow made with the jobbers, shares are dealt with at a premium before allotment, and the speculators, hoping to benefit in the rise and fall, are tempted to take a plunge. It is not business, it is pure gambling. The company we specially refer to is the Schanschieff Company, for a primary battery, with a capital of £200,000, of which £120,000 goes to the vendors, £30,000 is for working capital, and £50,000 is at present not issued. The prospectus says somebody has offered £40,000 for the Australian patents, or is to forfeit £2,000. Well, the forfeit should be paid, and even then the case will be one supporting the old adage that "a fool and his money are soon parted." The price given for this battery is out of all proportion to its value, and although we may agree with every word the experts have said in their testimonials, we contend that the statements made do not warrant any electrician venturing one share in the concern from a business point of view. Fancy—with £30,000 working capital—a nett return of £7,500 must be obtained to pay a 5 per cent. dividend. We again say we have every reason to believe that a good business could be made with this battery, but the enormous capital almost entirely vitiates any prospect of success. It is only a few days ago since Mr. Watt was showing specimens of pure zinc obtained by a process he has patented. Have the promoters of this Company thought of the effect the production of pure zinc will have in the construction of almost all primary batteries? Amalgamation will not be required; it will be a thing of the past, and therefore any patent depending upon amalgamation for its value will lose its all.

The tactics of the promoters in this, as in other cases, have been eminently successful. All that can be said by those who know the value of a primary battery is useless to warn investors that even such a battery may be dear at a price. One more company is added to the long list of ventures floated in such a manner as to strangle their business success at birth, and this is all the more deplorable in that the company really possesses a good and, in many respects, an excellent battery.

THE GREAT TELEPHONE CASE.

We have received from our namesake across the Atlantic a verbatim report of the decision in what may be termed the great telephone case of America. The decision related to no less than six appeals before the Supreme Court of the United States, in each of which the American Bell Telephone Company was on the one side, and Professor Dolbear, the Molecular Telephone Company, the Clay Commercial Telephone Company, the People's Telephone Company, and the Overland Telephone Company respectively, were on the other side, there being one cross appeal, making the six cases. The result is throughout in favour of the Bell Telephone Company. The decision, for example, supported a sufficiency of the specification. It says:—

"The law does not require that a discoverer or inventor, in order to get a patent for a process, must have succeeded in bringing the art to the highest degree of perfection. It is enough if he describes the method with sufficient clearness and precision to enable those skilled in the matter to understand exactly what the process is, and if he points out some practicable way of putting it in operation. This Bell did. He described clearly and distinctly his process of transmitting speech telegraphically by creating changes in the intensity of a continuous current or flow of electricity in a closed circuit, exactly analogous to changes of density in the air occasioned by the undulatory motion given to it by the human voice in speaking. He then pointed out two ways in which this might be done, one, by the vibration or motion of bodies capable of inductive action or by the vibration of the conducting wire itself in the neighbourhood of such bodies; and the other by alternately increasing and diminishing the resistance of the circuit or by alternately increasing and diminishing the power of the battery. He then states that he prefers to employ for his purpose an electro-magnet having a coil on one of its legs, and he describes the construction of the particular apparatus, shown in the patent as Figure 7, in which the electro-magnet or magneto method was employed. This was the apparatus which he himself used without entirely satisfactory results, but which Professor Cross, Mr. Watson, Doctor Blake, Mr. Pope, and others, testify has done and will do what was claimed for it, transmit speech successfully, but not as well indeed as another constructed upon the principle of the microphone or variable resistance method."

Part of the decision will no doubt be contested by Prof. Silvanus Thompson who, as is well known, is strongly in favour of Reis's claims, but this decision maintains that Bell's method is not in Reis's apparatus. The decision says:—

"It was left for Bell to discover that the failure was due not to workmanship, but to the principle which was adopted as the basis of what was to be done. He found that what he called the intermittent current, one caused by alternately opening and closing the circuit, could not be made, under any circumstances, to reproduce the delicate forms of the

air vibrations caused by the human voice in articulate speech; but that the true way was to operate on an unbroken current, by increasing and diminishing its intensity. This he called a vibratory or undulatory current, not because the current was supposed to actually take that form, but because that language expressed with sufficient accuracy his idea of a current which was subjected to gradual changes of intensity, exactly analogous to the changes of density in the air occasioned by its vibrations. Such was his discovery, and it was new. Reis never thought of it, and he failed to transmit speech telegraphically. Bell did, and he succeeded. Under such circumstances it is impossible to hold that what Reis did was an anticipation ot the discoveries of Bell. To follow Reis is to fail, but to follow Bell is to succeed. The difference between the two is just the difference between failure and success. If Reis had kept on he might have found out the way to succeed; but he stopped and failed. Bell took up the work and carried it on to a successful issue."

Similarly the decision deals with other anticipations, but it will be found that Mr. Justice Bradley, Mr. Justice Field and Mr. Justice Harlan were not able to concur with the other members of the Court in the result, so far as the question of Drawbaugh's invention was concerned.

UNDERGROUND CONDUCTORS FOR ELECTRIC CURRENTS.*

BY J. M. SMITH.

The question of underground conductors of electric currents is one which every person interested in electricity should study fairly and with a predetermination of solving. It is not purely an electrical question, in fact the electrical part of it is far overbalanced by the mechanical. There is no difficulty in finding an excellent insulating material, but the difficulty lies in the holding of this insulator on the conductor. Many substances are good insulators in dry places; some are good under water, some in damp places, and a few will stand acid and alkaline fumes and the ravages of sewer and illuminating gas, but how many will insulate under all these conditions, and in addition be substantial enough to withstand the mechanical injuries to which they are exposed when buried under the streets of our large cities? A few years ago wire wound around with a little cotton soaked in paraffin was thought sufficiently insulated until the insurance companies had a few losses, due, of course, to electricity, and then we had underwriter's wire. The name of this wire has sold hundreds of tons of it; but that does not prevent its grounding a whole system when it comes in contact with the least moisture. It, however, marks one state in the evolution of the perfect insulation. There seems to be comparatively little difficulty in making a cable that will carry high potential currents when constantly submerged. The conditions are substantially the same at all times. There are no alternate changes of moisture and dryness, no great changes of temperature, and very little of the destructive action of gases. The conditions of the underground conductor are very different. Here the conductor is dry, then wet; it is frozen, and again thawed; it is attacked by sewer gas, and the corroding action of the water leaching through the accumulated filth of the street; it is subject to the destructive action of the leaking gas and steam pipes, and finally, but not the less surely, to the ruthless "ditch digger." These are certainly formidable obstacles, but a number of them have already been overcome, and the others must be. Public opinion says the wires of all kinds must go under ground, and electricians, engineers, and capitalists must find the means of doing it.

The question resolves itself into three parts. First. The electrical insulation of the conductor. Second. The protection of the insulator from the effects of moisture and corrosion. Third. The protection of both from mechanical injury.

The question of electrical insulation seems to me to be solved by at least six of the standard compounds now in daily use.

The second part of the question is the most serious. If any of the standard insulations can be enclosed so as to be protected from direct contact with moisture their chances of life are certainly improved; but if they can be hermetically sealed, they should be practically indestructible provided the casing is indestructible. We single out as among the best materials from which to form such a casing—iron and lead. Cast iron, undergound, will last a great number of years, as shown by gas and water pipes, but it cannot be obtained in lengths much over 13ft., and the numerous joints multiply the chances of leakage. The conductors must of necessity be drawn into the pipe after it is in place. The conductor must be considerably smaller than the pipe, and therefore moisture will creep in between the two. Wrought-iron pipe, if well coated with asphalte or some similar substance, will last a long time. It may be had in longer lengths than the cast pipe, and the joints are more easily and surely made. If screw-threaded joints are used the conductors must be drawn in, with the same objections as with the cast pipes. If the lengths of pipe are prepared with the conductors in them before laying, joints must be made in the conductor, as well as in the casing, at short intervals. Joints are the bane of electrical construction. From the dynamo to the lamp and return the current is forced to pass joints which frequently offer more resistance than 1,000 feet of wire. At these joints the insulation, instead of being better than at other points of the conductor, is generally worse, and oftentimes none at all is found. It is not strange that the current should seek an easier path home, and take to ground, rather than be forced through the accumulated resistance of all these joints. I will venture to say that, of all the failures of underground conductors, 90 per cent. are directly traceable to the joints, and for that reason it is desirable to have as few as possible.

The conductor may be obtained in, practically, any length, and the insulation may be put on continuously; but in order to have a continuous casing it must be formed of some sort of ductile metal which can be closed about the insulated conductor in the course of its manufacture. Lead seems to be the only commercial metal that will find these conditions, and there are objections even to it. Lead is soft and easily punctured, and offers little resistance to crushing or bending, and is attacked by rats. On the other hand, the corrosive action of the earth has little effect upon it, while its pliable nature permits of its use in many places where iron pipes could not be used. Being soft and ductile it can be brought into such close contact with the insulation as to prevent, or at least retard, the creeping of moisture between the insulation and casing. It seems to me, therefore, that lead casing offers more advantages and less objection than any other form of protection to insulation as yet open to our use.

The third part of the question—viz., the mechanical protection of the casing, and hence the conductor—is not so difficult a matter. If an iron casing is used, little or no protection is needed. The pipe is strong enough in itself to withstand any ordinary abuse. If lead is used, however, it should be kept from contact with sharp stones, bits of glass, or metal, and have something about it to warn the ditch-digger before he strikes it with a pick. An ordinary square wooden box is oftentimes sufficient. If it does rot away it leaves a bed of soft mould. The box may be made of white oak, well creosoted, in which case it will last until the next generation finds something better. If the underground conductor is to come into practical

* Paper read before the Electric Light Convention at Pittsburgh.

every day use it must be so constructed that it may be tapped at any point as readily and with as much certainty as a water main is now tapped. How many miles of lead water pipes are now buried in our streets? They are not protected by boxes or conduits of any kind, yet it is comparatively rare that we hear of their failure. If such pipes filled with water can be laid in the earth without protection, why cannot a lead pipe filled solid full with copper and insulation be buried with even more success? Good workmen can certainly be found who can cut a conductor, splice in a branch and solder it, replace the insulation, and finally wipe a joint on the lead casing with as much ease and certainty as a plumber can make a joint in a lead water pipe and have it stand 100 pounds pressure.

In a general system of distribution there are two classes of conductors, one which we may call through mains or feeders and another service mains. A number of through mains may be bunched together in a cable under one casing, where they run in the same direction for a considerabledistance. These may be drawn into conduits, as they are not to be used between the main distributing points. Service mains must, however, be so constructed that they may be tapped at any point, and that very readily. Large sums of money have been spent in New York and elsewhere on conduits for electric conductors. Are conduits necessary or desirable in electric lighting? Service wires are of no use whatever if placed within them, unless manholes are provided at every 100 feet. Though mains are certainly well protected when drawn into conduits, but at a great expense, no engineer would, I think, at this day, risk putting a conductor in any conduit which he would not be willing to trust under water or laid directly in the earth. Why not take one-half of the money which these conduits cost and use it in buying thicker lead casing and bury the conductor in the ground or in a common wooden box?

The underground conductor of the future, I believe, will be formed with a core of copper cable, thoroughly insulated by any of the standard and well-tried compounds, protected by a close-fitting lead casing, thick enough to resist mechanical injury, and buried in the earth in such a manner that it may be tapped at any point. But where is the money coming from to pay for these conductors? Whenever electric light plants are installed in a thoroughly mechanical and substantial manner, with due regard to the most economical production of power, so that the electric light is perfectly reliable and obtains public confidence, then the money will be forthcoming.

When capital enough is invested in electric lighting to enable it to cope with the vast sums which have been accumulating these many years in the gas industry, then we shall see our dynamos driven by the waste heat and refuse products of the gas works, and our houses will be heated by gas and lighted by electricity.

ELEMENTS AND META-ELEMENTS.*

BY WILLIAM CROOKES, F.R.S.

Permit me, gentlemen, now to draw your attention for a short time to a subject which concerns the fundamental principles of chemistry, a subject which may lead us to admit the possible existence of bodies which, though neither compounds nor mixtures, are not elements in the strictest sense of the word—bodies which I venture to call "meta-elements." To explain my meaning it is necessary for me to revert to our conception of an element. What is the criterion of an element? Where are we to draw the line between distinct existence and identity? No one doubts that oxygen, sodium, chlorine, sulphur, are separate elements; and when we come to such groups as chlorine, bromine, iodine, &c., we still feel no doubt, although were degrees of "elementicity" admissible—and to that we may ultimately have to come—it might be allowed that chlorine approximates much more closely to bromine than to oxygen, sodium, or sulphur. Again, nickel and cobalt are near to each other, very near, though no one questions their claim to rank as distinct elements. Still I cannot help asking what would have been the prevalent opinion among chemists had the respective solutions of these bodies and their compounds presented identical colours, instead of colours which, approximately speaking, are mutually complementary. Would their distinct nature have even now been recognised? When we pass further and come to the so-called rare earths the ground is less secure under our feet. Perhaps we may admit scandium, ytterbium, and others of the like sort to elemental rank; but what are we to say in the case of praseo- and neo-dymium, between which there may be said to exist no well-marked chemical difference, their chief claim to separate individuality being slight differences in basicity and crystallising powers, though their physical distinctions as shown by spectrum observations are very strongly marked? Even here we may imagine the disposition of the majority of chemists would incline towards the side of leniency, so that they would admit these two bodies within the charmed circle. Whether in so doing they would be able to appeal to any broad principle is an open question. If we admit these candidates, how in justice are we to exclude the series of elemental bodies or meta-elements made known to us by Krüss and Nilson? Here the spectral differences are wel marked, while my own researches on didymium show also a slight difference in basicity between some at least of these doubtful bodies. In the same category must be included the numerous separate bodies into which it is probable that yttrium, erbium, samarium, and other "elements"—commonly so-called—have been and are being split up. Where, then, are we to draw the line? The different groupings shade off so imperceptibly the one into the other that it is impossible to erect a definite boundary between any two adjacent bodies and to say that the body on this side of the line is an element, while the one on the other side is non-elementary, or merely something which simulates or approximates to an element. Wherever an apparently reasonable line might be drawn it would no doubt be easy at once to assign most bodies to their proper side, as in all cases of classification the real difficulty comes in when the border-line is approached. Slight chemical differences of course are admitted, and, up to a certain point, so are well-marked physical differences. What are we to say, however, when the only chemical difference is an almost imperceptible tendency for the one body—of a couple, or of a group—to precipitate before the other? Again, there are cases where the chemical differences reach the vanishing point, although well-marked physical differences still remain. Here we stumble on a new difficulty; in such obscurities, what is chemical and what is physical? Are we not entitled to call a slight tendency of a nascent amorphous precipitate to fall down in advance of another a "physical difference?" And may we not call coloured reactions, depending on the amount of some particular acid present, and varying according to the concentration of the solution and to the solvent employed "chemical differences?" I do not see how we can deny elementary character to a body which differs from another by well-marked colour, or spectrum reactions, while we accord it to another body whose only claim is a very minute difference in basic powers. Having once opened the door wide enough to admit some spectrum differences, we have to inquire how minute a difference qualifies the candidate to a pass? I will give instances from my own experience of some of these doubtful candidates. 1. Two closely allied bodies differ slightly in basic powers, and more decidedly also in their spectrum reactions; are they distinct entities? Probably, yes. 2. Two bodies have no distinctive spectrum reaction, and differ in basicity so slightly that their separation has hitherto proved to be impossible; but they differ decidedly in the colour of their oxides. Are they different? I should in this case also say yes. 3. Two bodies obtained from different minerals have no recognisable chemical difference, but there is a stron line in the phosphorescent spectrum of one which is absen in the other. What are we to say in this case? 4. A earth separated with enormous difficulty from its associat has a certain very definite phosphorescent spectrum. T addition of another body greatly intensifies one or more the lines of the spectrum of the earth so separated, wh upon the other lines in the spectrum of the same earth has no action. Is the basis of this earth simple or c

* Presidential Address to the Chemical Society.

pound? 5. An earth showing no difference on fractionation has a phosphorescent spectrum not materially modified by the admixture of another earth; but the residual glow of one part of the spectrum as seen in the phosphoroscope is suppressed, while that of the other is not affected. Are we not here also dealing with more than one sort of molecule? 6. Earths, apparently the same, from different minerals, behave alike chemically and spectroscopically, with the exception that a certain line in the spectrum of the one is a little brighter than the corresponding line in the spectrum of the other. Again, where are we to draw the line? If an immediate decision were required, and a poll of the chemists in this room demanded, we should probably find the dividing lines placed in all positions among these seven cases. But to have only one rank in the elementary hierarchy, to class these obscure and indefinite bodies in the same rank with silver and chlorine and oxygen and sulphur, is as manifest an absurdity as it would be to put a speck of meteoric dust upon a level with the planet Jupiter because both may be called distinct members of the solar system. Is there no way out of this perplexity? Must we either make the elementary examination so stiff that only some 60 or 70 candidates can pass, or must we open the examination doors so wide that the number of admissions is limited only by the number of applicants? The real difficulty we encounter by unlimited multiplication of elements arises from the periodic theory. That theory has received such abundant verification that we cannot lightly accept any interpretation of phenomena which fails to be in accordance with it. But if we suppose the elements reinforced by a vast number of bodies slightly differing from each other in their properties, and forming, if I may use the expression, aggregations of nebulæ where we formerly saw, or believed we saw, separate stars, the periodic arrangement can no longer be definitely grasped. No longer, that is, if we retain our usual conception of an element. Let us, then, modify this conception. For "element" read "elementary group"—such elementary groups taking the place of the old elements in the perodic scheme—and the difficulty falls away. In defining an element, let us take not an external boundary, but an internal type. Let us say, *e.g.*, the smallest ponderable quantity of yttrium is an assemblage of ultimate atoms almost infinitely more like each other than they are to the atoms of any other approximating element. It does not necessarily follow that the atoms shall all be absolutely alike among themselves. The atomic weight which we ascribe to yttrium, therefore, merely represents a mean value around which the actual weights of the individual atoms of the "element" range within certain limits. But if my conjecture is tenable, could we separate atom from atom, we should find them varying within narrow limits on each side of the mean. The very process of frationation implies the existence of such differences in certain bodies. Until lately such bodies passed muster as elements. They had definite properties, chemical and physical; they had recognised atomic weights. If we take a pure dilute solution of such a body, yttrium for instance, and if we add to it an excess of strong ammonia, we obtain a precipitate which appears perfectly homogeneous. But if instead we add very dilute ammonia in quantity sufficient only to precipitate one-half of the base present, we obtain no immediate precipitate. If we stir up the whole thoroughly so as to insure a uniform mixture of the solution and the ammonia, and set the vessel aside for an hour, carefully excluding dust, we may still find the liquid clear and bright, without any vestige of turbidity. After three or four hours, however, an opalescence will declare itself, and the next morning a precipitate will have appeared. Now let us ask ourselves, What can be the meaning of this phenomenon? The quantity of precipitant added was insufficient to throw down more than half the yttria present, therefore, a process akin to selection has been going on for several hours. The precipitation has evidently not been effected at random, those molecules of the base being decomposed which happened to come in contact with a corresponding molecule of ammonia, for we have taken care that the liquids should be uniformly mixed, so that one molecule of the original salt would not be more exposed to decomposition than any other. If, further, we consider the time which elapses before the appearance of a precipitate, we cannot avoid coming to the conclusion that the action which has been going on for the first few hours is of a selective character. The problem is not why a precipitate is produced, but what determines or directs some atoms to fall down and others to remain in solution. Out of the multitude of atoms present, what power is it that directs each atom to choose the proper path? We may picture to ourselves some directive force passing the atoms one by one in review, selecting one for precipitation and another for solution till all have been adjusted. In order that such a selection can be effected there evidently must be some slight differences between which it is possible to select, and this difference almost certainly must be one of basicity, so slight as to be imperceptible by any test at present known, but susceptible of being nursed and encouraged to a point when the difference can be appreciated by ordinary tests. Let us follow our atoms through another stage of fractionation. The ammonia has divided them into two groups, one of which displays just the minutest possible suspicion of greater basicity than the other. Let us repeat the first experiment again with these two groups. Again, we obtain from each a precipitate and a solution, so that we have now two precipitates and two solutions. It is evident that whereas the precipitate from the orginal salt was slightly less basic than that which remained dissolved, the second precipitate from the first precipitate must have its basic character still further diminished, while at the same time the second solution from the first solution must contain selected atoms of a slightly higher degree of basicity. The least basic at one end and the most basic at the other end are thus two removes each from the original; and treating them in the same way for a third time, we obtain two groups of atoms which are three removes from the centre. (The intermediate groups need not be here discussed. By systematic mixings they can be made to contribute their quota to the end groups.) By repeating this operation, not once or twice, but many hundreds of times, those atoms having a tendency to come down first always going one way, and those having a tendency to remain dissolved always going the other way, we, so to speak, educate the atoms, adding to them no fresh properties, but drawing out and giving free scope to properties that already existed, but that were previously masked. A similar absence of absolute homogeneity may possibly yet be traced in many of the "elements" if once the right reagents are selected, and if laborious chemists are to be found willing to devote years to researches barren to outward seeming. That this deviation from absolute homogeneity should mark the constitution of these molecules or aggregations of matter which we designate elements will perhaps be clearer if we return in imagination to the earliest dawn of our material universe, and, face to face with the Great Secret, try to consider the processes of elemental evolution. Going back to the "fire-mist," the "Ur-Stoff" of the German philosophers, or the "protyle," as, after Roger Bacon, I have ventured to call it, we see an infinite number of infinitely small ultimate, or rather ultimatissimate particles gradually accreting out of "formless stuff" and moving with inconceivable velocity in all directions. We find those particles which approximately have the same rate and modes of movement beginning to heap themselves together by virtue of that ill-understood tendency through which like and like come together—that principle by virtue of which identical or approximately identical bodies are found collected in masses in the earth's crust instead of being uniformly distributed. One of the first results of this massing tendency is the formation of certain nodal points in space, between which occur approximately void intervals. How such nodes and spaces come to be formed, we shall better be able to understand by a very few simple illustrations, choosing in the first instance, instead of ultimate atoms, living men and women. If we take any very frequented street in London, say, Fleet-street, at a time when the animated current runs pretty equally in two directions; and if our rate of walking is somewhat greater than the mean speed of the other foot-passengers, we shall observe that the throngs on the foot-ways are not evenly distributed, but consist of knots or groups—we might almost say blocks—with comparatively open intervening spaces. The explanation of this unequal

agglomeration of individuals is simple. Some two or three persons, whose rate of working is slower than the average, somewhat retard the movements of other persons, whether travelling in the same or in the opposite direction. In this manner a slight temporary obstruction is created. The persons behind catch up the obstruction, and so increase it; while those in the front of the obstruction, hurrying on unhindered at their former rate, leave a comparatively free and open space until they, too, find themselves delayed further on by another little group of loiterers. The same process may be observed with vehicles in the carriage-way of much frequented streets. Thus, we find that differences in rate of movement are sufficient to arrange a multitude of moving bodies into a series of knots and gaps. In a crowded thoroughfare like Fleet-street, with two opposing human currents, much regularity in the sequence of these knots and voids is not to be expected; but if the observer happens to be walking with a crowd whose constituents are travelling in the same direction, the regularity becomes more apparent; and if, as is sometimes the case, a little rhythm is infused into the step by an accompaniment of music, the knots and gaps become so orderly that the distance between one block and another, measured in yards, will be found not to differ very greatly from one end of the road to the other. If, instead of men and women, we experiment with little grains of substances of approximately equal size, but differing in specific gravity, and, mixing them in a horizontal tube with water, we set them in movement by rhythmical agitation, similar phenomena will occur, and the heavy and light powders will sort themselves in a very regular manner. Descending to a lower degree of minuteness, we all know what occurs when an induction current is passed through a rarefied gas. Here the particles, being exempt from free will or caprice, implicitly obey the law I have attempted to illustrate, and out of infinite disorder, under the influence of the electric rhythm, sort themselves into beautiful forms of stratifications. Let us now return to our ultimate atoms, where the case, though much more complicated, is of the same character. We will suppose certain points in space where the first step in differentiation has been achieved. The ultimate particles have commenced to vibrate in their newborn energy in all directions, and with velocities ranging from zero to infinity. The law which we have traced from animated beings and coarse powders, down to the molecules of a rarefied gas, still holds good at this transcendental stage of matter, and the imagination can picture knots and voids gradually forming there as well as in Fleet-street. The slower particles will obstruct the quicker, the more rapid will rush up to the laggards in front, and we shall soon have groups forming in different parts of space. The constituents of each group whose rate of vibration is not in accord with the mean rate of the bulk of the components of that group will work to the outside and be thrown off to find other groups with which they are more in harmony. In time, therefore, a condition of stability is established between the various groups, and we may call these the molecules of our present system of elementary bodies. With regard to the place where atoms come into existence, it seems to me almost certain that if their existence has had a beginning, it has begun at the very edge of the protyle, or the confines of the universe, and that their subsequent migrations have always been inwards. In dynamical language every new position into which an atom can glide must be from a position of higher to a position of lower potential. If the atom has had a beginning is must therefore have been where the potential is highest—*i.e.*, on the confines of the universe; and if it comes to an end, it must be where the potential is lowest, *i.e*, in the centre of overgrown stars; so that the extinction of the central part of a star when it becomes overgrown is that which puts a limit to the size a star can attain by attracting to itself surrounding matter. This assigning of the places where chemical atoms have their origin and where they meet with extinction seems the only—or almost the only—conclusion we can yet with confidence advance. From the above illustrations it will be seen that the constituent atoms of these molecules originally may not have been gifted with exactly the same speed or amplitude of vibration. In the molecule of a certain group let the form of energy which has for a factor what we call atomic weight be represented by the figure 35·5; it follows from the foregoing exposition —which I have endeavoured to make clear—that while the great bulk of its component atoms have this atomic weight, a small percentage may vary from this figure to the extent of a decimal place, while a few others may stray as much as a whole number or two on one side or the other of the mean. The ultimate atoms whose rates are not exactly 35·5, but a little higher or lower than 35·5, will congregate around the 35·5 nucleus, forming a group whose average value will be 35·5. In like manner similar groups will be formed having the average rates of 80 and 127, while intermediate spaces will be cleared, the ultimate atoms which occupied these lone spaces being attracted to the chlorine, bromine, and iodine groupings. These groupings represent what at present we call elements, but which I conjecture may possibly consist each of an element and of a certain number of meta-elements, or each may be formed of a whole group of meta-elements, none of which greatly preponderate over the remainder. On the threshold we encounter an objection very clearly stated by Clerk-Maxwell in his "Theory of Heat" (1871). "I do not think," says this eminent physicist, "that the perfect identity which we observe between different portions of the same kind of matter can be explained on the statistical principle of the stability of the averages of large numbers of quantities, each of which may differ from the mean, for if of the molecules of some substance, such as hydrogen, some were of slightly greater mass than others, we have the means of producing a separation between molecules of different masses, and in this way we should be able to produce two kinds of hydrogen, one of which would be somewhat denser than the other. As this cannot be done, we must admit that the quality which we assert to exist between the molecules of hydrogen applies to each individual molecule, and not merely to the average of groups of millions of molecules. The molecules of the same substance are all exactly alike, but different from those of other substances. There is not a regular gradation in the mass of molecules from that of hydrogen, which is the least of those known to us, to that of bismuth; but they all fall into a limited number of classes or species, the individuals of each species being exactly similar to each other, and no intermediate links are found to connect one species with another by a uniform gradation. In the case of molecules, however, each individual is permanent; there is no generation or destruction, and no variation, or rather no difference, between the individuals of each species. Our molecules are unalterable by any of the processes which go on in the present state of things, and every individual of each species is of exactly the same magnitude, as though they had all been cast in the same mould like bullets, and not merely selected and grouped according to their size like small shot." I think it evident that the statements here quoted, some of which involve no small amount of assumption, no longer accord with facts, for we actually do find variations between the properties of certain molecules which heretofore had been pronounced identical with each other. Take the case of yttrium. It had its definite atomic weight, it behaved in every respect as a simple body, an element, to which we might indeed add, but from which we could not take away. Yet this yttrium, this supposed homogeneous whole, on being submitted to a certain method of fractionation is resolved into portions not absolutely identical among themselves, and exhibiting a gradation of properties. Or take the case of didymium. Here was a body betraying all the recognised characters of an elements. It had been separated with much difficulty from other bodies which approximated closely to it in their properties, and during this crucial process it had undergone very severe treatment and very close scrutiny. In short, until lately we might have said of it just what Clerk-Maxwell says of hydrogen, that the quality which we assert to exist between the molecules of didymium applies to each individual molecule, and not merely to the average of groups of millions of molecules. But then came another chemist, who, treating this assumed homogeneous body by a peculiar process of fractionation, resolved it into the two bodies praseodymium and neodymium, between which certain distinctions are per-

ceptible. Further, we even now have no certainty that neodymium and praseodymium are simple bodies. On the contrary, they likewise exhibit symptons of splitting up. Now, if one supposed element on proper treatment is thus found to comprise dissimilar molecules, we are surely warranted in asking whether similar results might not be obtained in other elements, perhaps in all elements, if treated in the right way. We may even ask where the process of sorting-out is to stop—a process which of course presupposes variations between the individual molecules of each species. And in these successive separations we naturally find bodies approaching more and more closely to each other. Dr. Auer von Welsbach, the discoverer of neodymium and praseodymium, remarks that these bodies "approximate more closely to each other than any two supposed simple bodies yet known." Thus we approach nearer and nearer either to a regular gradation in the molecules or to the recognition of those intermediate links, which I have named "meta-elements" or elementoids. A suggestion here occurs that it may be to the presence of these meta-elements that so many of the chemical elements, while approaching closely in their atomic weights the values required by Prout's law, deviate from it by a small but measurable amount. We can scarcely regard their approximation as purely accidental. We now come to the last objection pertinently put forth by Clerk-Maxwell to the hypothesis that the elements are not absolutely homogeneous. He writes:—"It is difficult to conceive of selection and elimination of intermediate varieties, for where can these eliminated molecules have gone to if, as we have reason to believe, the hydrogen, &c., of the fixed stars is composed of molecules identical in all respects with our own?" In the first place, we may call in question this absolute molecular identity, since we have hitherto had no means for coming to a conclusion save the means furnished by the spectroscope, while it is admitted that for accurately comparing and discriminating the spectra of two bodies they should be examined under identical states of temperature, pressure, and all other physical conditions. We have certainly seen, in the spectrum of the sun, rays which we have not been able to identify. We have supposed the cosmic cycle re-entering in successive periods, during a fall of temperature, the same region—say, for instance, where chlorine, bromine, or iodine have been formed. If most of the atoms present approximate more or less closely to 35·5, 80, or 127—the atomic weights of these three bodies—they will be in consequence easily disposed of. But there may be besides a few intermediate atoms having, say, atomic weights of between 36 and 79 and between 81 and 126. These atoms will be attracted to the masses on one side or the other of the cyclical track. We can even imagine sparse atoms scattered so far from the centre line of track as to be midway between chlorine or bromine or between bromine and iodine; these wanderers likewise will be slowly picked up, and will gravitate to chlorine, bromine, or iodine; and, being thus accounted for, none need be eliminated. It is not impossible, moreover, that the elementary atoms themselves are not the same now as when first generated. For if an atom has commenced its existence at a certain epoch, and may go through such vicissitudes that it will cease to exist, it seems at least probable that it may undergo inward change. These vicissitudes probably directly affect only the primary motions which constitute the existence of the atom, but they indirectly, and only in a slight degree, affect those secondary motions which produce all the effects we can observe—chemical effects, heat effects, electrical, and so on. Thus, while the life of an atom may be waning away under the various experiences to which it is subjected, it may, and probably does, appear to us the same as at first. But perhaps not quite, so that atoms originally alike, taken from different minerals collected at widely separated stations on the earth, may have had sufficiently different past histories to have come to be markedly different in regard to the primary motions which elude our observation, and through the very slight influence which changes in the primary motions have on the secondary motions, may be just perceptibly different under our experiments. From this point of view a rare element, like a rare plant or animal, is one which has failed to develop in harmony with its surroundings. This view lends itself very naturally to the facts we encounter in our fractionation experiments. Where all the ultimate atoms have precisely identical rates of vibration any fractionation is impossible. Where such rates are not identical the process proves successful, and all the more easily the wider the differences among the vibration-rates of the ultimate atoms. The bodies thus split off necessarily very closely approximate to each other, and the further we push our fractionations the less marked are the differences. But as we review the series of elements arranged on the curve I adopted from Prof. Emerson Reynolds to illustrate my address on the "Genesis of the Elements," delivered before the chemical section of the British Association (Birmingham meeting), we cannot fail to be struck by a consideration which at first sight appears absolutely fatal to the notion of the production of the elements from a series of "knots," as just described. If the element which we call aluminium has been formed from ultimate atoms having rates of vibration of the rate 27, or a little more or less so as to give a mean of 27, and if the atoms between aluminium and the next element in the series have in this manner been sorted out to the one hand or the other, leaving a void between, we should expect that their properties would not differ very widely from each other, or at least that they would present considerable analogies. Now, to a certain extent this is actually the case. Upon aluminium follows silicon. We may, perhaps, conceive these two elements as springing from the differentiation of a nearly homogeneous swarm of ultimate atoms. But if we pursue the curve onwards what elements follow? Phosphorus, sulphur, and chlorine—bodies heterologous with each other, and heterologous with silicon. We can scarcely imagine original atoms, so to speak, in doubt which of two aggregations they should join, the one being silicon and the other phosphorous. Nor can we conceive of anything being split off from sulphur which should make even the slightest approximation to chlorine. It appears to me, however, that these difficulties are more apparent than real. In the Birmingham address already referred to I asked my audience to picture the action of two forces on the original protyle—one being time, accompanied by a lowering of temperature; the other, swinging to and fro like a mighty pendulum, having periodic cycles of ebb and swell, rest and activity, being intimately connected with the imponderable matter, essence or source of energy we call electricity. Now, a simile like this effects its object if it fixes in the mind the particular fact it is intended to emphasize, but it must not be expected necessarily to run parallel with all the facts. Besides the lowering of temperature with the periodic ebb and flow of electricity, positive or negative, requisite to confer on the newly-born elements their particular atomicity, it is evident that a third factor must be taken into account. Nature does not act on a flat plane; she demands space for her cosmogenic operations, and if we introduce space as the third factor all appears clear. Instead of a pendulum, which, though to a certain extent a good illustration, is impossible as a fact, let us seek some more satisfactory way of representing what I conceive may have taken place. Let us suppose the zigzag diagram not drawn upon a plane, but projected in space of three dimensions. What figure can we best select to meet all the conditions involved? Many of the facts can be well explained by supposing the projection in space of Prof. Emerson Reynolds's zigzag curve to be a spiral. This figure is, however, inadmissible, inasmuch as the curve has to pass through a point neutral as to electricity and chemical energy twice in each cycle. We must therefore adopt some other figure. A figure of eight or lemniscate will foreshorten into a zigzag just as well as a spiral, and it fulfils every condition of the problem. Such a figure will result from three very simple simultaneous motions. First, a simple oscillation backwards and forwards (suppose east and west); secondly, a simple oscillation at right angles to the former (suppose north and south) of half the periodic time, *i.e.*, twice as fast; and thirdly, a motion at right angles to these two (suppose downwards), which, in its simplest form, would be with unvarying velocity. If we project this figure in space we find on examination that the points of the curves where chlorine, bromine, and iodine are formed come close under each other; so also will sulphur, selenium, and telle-

rium; again, phosphorus, arsenic, and antimony; and in like manner other series of analogous bodies. It may be asked whether this scheme explains how and why the elements appear in this order? Let us imagine a cyclical translation in space, each revolution witnessing the genesis of the group of elements which I previously represented as produced during one complete vibration of the pendulum. Let us suppose that one cycle has thus been completed, the centre of the unknown creative force in its mighty journey through space having scattered along its track the primitive atoms—the seeds, if I may use the expression—which presently are to coalesce and develop into the groupings now known as lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, sodium, magnesium, aluminium, silicon, phosphorus, sulphur, and chlorine. What is most probably the form of track now pursued? Were it strictly confined to the same plane of temperature and time, the next elementary groupings to appear would again have been those of lithium, and the original cycle would have been eternally repeated, producing again and again the same 14 elements. The conditions, however, are not quite the same. Space and electricity are as at first, but temperature has altered, and thus, instead of the atoms of lithium being supplemented with atoms in all respects analogous with themselves, the atomic groupings, which come into being when the second cycle commences, form, not lithium, but its lineal descendant, potassium. Suppose, therefore, the *vis generatrix* travelling to and fro in cycles along a lemniscate path as above suggested, while, simultaneously, temperature is declining and time is flowing on—variations which I have endeavoured to represent by the downward sink—each coil of the lemniscate track crosses the same vertical line at lower and lower points. Projected in space, the curve shows a central line neutral as far as electricity is concerned and neutral in chemical properties—positive electricity on the north, negative on the south. Dominant atomicities are governed by the distance east and west from the neutral centre line, monatomic elements being one remove from it, diatomic two removes, and so on. In every successive coil the same law holds good. As the mighty focus of creative energy goes round we see it in successive cycles sowing in one tract of space seeds of lithium, potassium, rubidium, and cæsium; in another tract, chlorine, bromine, and iodine; in a third, sodium, copper, silver, and gold; in a fourth, sulphur, selenium, and tellurium; in a fifth, beryllium, calcium, strontium, and barium; in a sixth, magnesium, zinc, cadmium, and mercury; in a seventh, phosphorus, arsenic, antimony, and bismuth; in other tracts, aluminium, gallium, indium, and thallium; silicon, germanium, and tin; carbon, titanium, and zirconium; while a natural position, near the neutral axis, is found for the three groups of elements relegated by Prof. Mendeleeff to a sort of hospital for incurables—his eighth family. We have now traced the formation of the chemical elements from knots and voids in a primitive, formless fluid. We have shown the possibility, nay, the probability, that the atoms are not eternal in existence, but share, with all other created beings, the attributes of decay and death. We have shown, from arguments drawn from the chemical laboratory, that in matter which has responded to every test of an element, there are minute shades of difference which may admit of selection. We have seen that the time-honoured distinction between elements and compounds no longer keeps pace with the developments of chemical science, but must be modified to include a vast array of intermediate bodies—"meta-elements." We have shown how the objections of Clerk-Maxwell, weighty as they are, may be met; and, finally, we have adduced reasons for believing that primitive matter was formed by the act of a generative force, throwing off at intervals of time atoms endowed with varying quantities of primitive forms of energy. If we may hazard any conjectures as to the source of energy embodied in a chemical atom, we may, I think, premise that the heat radiations propagated outwards through the ether from the ponderable matter of the universe, by some process of nature not yet known to us, are transformed at the confines of the universe into the primary—the essential—motions of chemical atoms, which, the instant they are formed, gravitate inwards, and thus restore to the universe the energy which otherwise would be lost to it through radiant heat. If this conjecture be well founded, Sir William Thomson's startling prediction of the final decrepitude of the universe through the dissipation of its energy falls to the ground. In this fashion, gentlemen, it seems to me that the great question of the elements may be provisionally treated. Our slender knowledge of these first mysteries is extending steadily, surely, though slowly. While certain ardent chemists are testing the commonly received view of the homogeneity of the elements by methods of fractionation, others, by means of the spectroscope, are carrying on another form of assault; each worker bent on the one idea of undermining the secret. I earnestly recommend such researches. However successfully pursued, they cannot, I know, lead directly to any results capable of being turned to industrial account. If, however, we consider the small but firm foothold we have gained in pursuit of this line of investigation, I venture to think there is reasonable ground to hope that these researches may tend to place chemistry upon a new foundation, by penetrating down through loose, superficial matter to the solid rock. The application of the luminous principle of evolution has remodelled and vivified many branches of biology, and philosophers are eagerly invoking its aid in other departments of science. I would fain hope that I may not be deemed unduly sanguine in believing that the application of this regenerating principle to chemistry will produce far-reaching effects on its harmonious and progressive development.

THE UNDERGROUNDING OF ELECTRIC ARC WIRES.*

BY W. W. LEGGETT.

(Concluded from page 305.)

The question is frequently asked, If telephone and telegraph wires can be undergrounded, why cannot arc wires? The reason is plain; leakage or escape can be supplied in the former by additional battery power, but an arc light generator is a queer specimen of mechanics. It starts a mild current, and this passing back around its field magnets builds them up; the increased magnetism induces greater impulses in the bobbins of the armature the current thus increased continues to pass through the line and back around the field magnets until the current has reached its maximum. It is therefore apparent that anything which keeps the current from the line, not only steals the quantity which has escaped, but prevents just so much current from passing back around the field magnets, and to that extent robs the machine of its capacity to generate a current. These machines are capable of taking care of the small amount of loss at the insulators in the pole and line system, but when this is multiplied many times, as in an underground conduit, it is so robbed of its power to recuperate that the resulting lights are necessarily reduced in number, and are weak and sickly. Operations looking to the undergrounding of arc light wires have been prosecuted on a large scale at New York, Brooklyn, Chicago, Philadelphia, and Washington. Notwithstanding all reports to the contrary, I find that at New York, although the Subway Commission has expended vast sums of money, and has succeeded in burying certain telephone and telegraph wires, no arc light line has up to this time been buried in New York city, and this is fully corroborated by the report of the Board of Electrical Control of January 6, 1888.

At Brooklyn, N.Y., the Board of Commissioners of Electrical Surveys instituted thorough investigation of this subject in 1886, and in its report of December 30, 1886, says:—"With regard to electric light conductors this board has found no device which would with certainty, in its opinion, enable the wires carrying arc light currents to be safely and successfully operated in the same conduit with telephone and telegraph conductors without disturbance or injury to the latter. But the board desires to say, emphatically, that those fluent critics who talk of putting electric light conductors

* Paper read before the National Electric Light Convention at Pittsburgh.

underground, making no distinction between arc lights and incandescent lights, or between the arc lights of different systems, are ignorant of the alphabet of the subject." The president of the board visited all the principal cities in Great Britain and Europe. He found no arc light wires underground, and although a few years since such wires were trained in the Paris sewers, they have been removed, and no arc light wires are now allowed therein.

The Booklyn Commission made another report, December 15, 1887, and on this topic says:—"As was fully explained in the last report, the subject of underground conduits for arc currents is the one which presents the most numerous and novel difficulties. Since it has been impossible for Brooklyn to take the lead in the experimental solution of these, the only remaining course was to watch carefully the progress of experiments in other cities. This has been done both by correspondence and by personal visits of members of the board. The principal cities in which experiments of this kind have been in progress are New York, Chicago, Philadelphia, Baltimore, and Washington. In one or another of these several systems which were regarded with favour a year ago have since developed defects or even come to entire failure. It cannot be said that any system has yet been completely proved to be permanently satisfactory. There are one or two, however, which promise well, and this board awaits with attentive interest their further trial, regretting only its inability, through the cause already specified, to co-operate in the experimental investigation of the different and delicate questions involved." There are no arc light wires underground up to this time in Brooklyn.

At Washington in 1884 cables were laid in F street from 9th to 15th. In a few months it was necessary to dig up the same. Later, there was much more trouble, and it was all taken up and relaid. About one year after the first laying it was wholly abandoned because they could not make it work. In 1885 they laid cables on Pennsylvania-avenue, from 9th to 1st streets, and imported an expert from Antwerp to lay them. Twelve cables were laid in solid cement, and no expense spared to insure success. They proved an utter failure. The avenue was dug up many times. The wires were in September, 1887, mostly out of service, and the remainder were in such bad shape that they would require constant repairing or have to be abandoned. An officer of the Washington company writes me under date of September 12, 1887:—"We have many committees coming here to see what we have accomplished, as they have heard that we have met with great success and so forth. We will say to you, that our experience, after the outlay of many thousand dollars, is this: have nothing to do with underground cables for arc lighting if you can possibly avoid it. Many will tell you that it is perfectly practicable. Look out for such parties. They are probably interested directly or indirectly in cables. There is a big hobby in that branch of business. There is no city or town in the world where a cable has been made to work two years that has been subjected to 2,000 volts of pressure." This Washington company is using lead-covered cables with success for incandescent work; but as to the undergrounding of arc light wires, confirmed as late as Feb. 7, 1888, they report that out of 14 miles of arc light cable in 14 different circuits all have proved total failures, and have been abandoned except a very small amount.

At Philadelphia elaborate experiments have been prosecuted. All kinds of cables have been employed, and a great variety of conduits—great trouble has been experienced. The systems largely employed were such having ducts through which the cables were drawn—in most cases the insulating compound rapidly deteriorated, and became useless; in others it would be rotted, and become water soaked. Where lead-covered cables were used in conduits where creosote was employed, the effect was to rapidly oxidise the lead covering, and disintegrate the same. It was found that gas could not be kept from the ducts; although apparently gas tight, many explosions followed. Recourse was then had to ventilation by lamp posts, but the trouble was not corrected. After several explosions in one system, in which persons and property were injured, a power fan was adjusted to force air through the conduit, deeming it better to do so, than to draw the air through, which might simultaneously draw in gas. When, shortly afterwards, the lighting company was congratulating itself that it had overcome the difficulty, a tremendous explosion ensued, extending for a long distance, ripped up the street, and broke a large plate glass window. That entire system of lights had to be abandoned. It was some six months ago determined by the manager that as a result of experience no conduit would suffice for arc light wires in which there were open ducts, and that success lay in the employment of lead covered cables buried solid. This plan suggested by the city electricians was tried and success seemed assured, but they now report the experiment unsuccessful. The section covered is not great, but three bad grounds recently developed; two were repaired, but the third necessitated the temporary cutting out of a part of the line and the training of wires on poles until the earth may thaw and enable access to be had to the wires. The various companies of Philadelphia are at a loss what to try next. At this point I would note that these demands for a system for arc light wires have greatly stimulated inventive ingenuity, but as yet without success. Out of the 72 patents that have been issued in this line, 53 of them have emanated from Philadelphia, New York, Boston, Brooklyn, Wilmington, Camden and Washington, all being in the immediate vicinity of the places where the operations were being conducted. The others were mostly from the general vicinity of Chicago.

Now as to Chicago, much has been said of its system. A visit to Chicago satisfied me that its electric arc light industry was being strangled. A few blocks in the immediate heart of the city were using electric light very lavishly, but the area lighted is scarcely a half mile square. This small area is served from no less than nine separate plants, formerly belonging to as many companies, but now consolidated into one. A letter under date of September 20, from an officer of the Consolidated Company, explains the situation there. He says:—"We have had an enormous amount of trouble with our underground arc light circuits, averaging, I would say, for the last three months, one burn out every day. The expense of reconstruction and the losses in rebates have been enormous, and the annoyance to our customers more damaging still. Commencing in April last we bought out some nine arc light plants in Chicago, and have proceeded to concentrate them into four main stations burning about 1,100 lights; their owners had all been using underground conductors composed for the most part of okonite, kerite, callender, and underwriter's wires. Every one of these insulators has failed constantly. The only thing that has held up at all is lead covered cable, and we have been driven to the great expense of taking out every foot of the old constructions and substituting new lead covered cables throughout. This work is not yet done. Our people are confident that a large business awaits us here; but its development will depend entirely upon service. These lead circuits may fail much sooner than is anticipated, and it is almost certain that we shall be compelled to reduce the number of lights upon a circuit—a very difficult matter in a city like Chicago. Our conduit space is already filled along the main routes, and additional conduits will be necessary. The constant tearing up of the pavements for all kinds of purposes makes our street departments very unwilling to grant permits for laying additional conduits, and several times they have been refused altogether. I would say here that arc light business in Chicago has developed entirely since the passage of the underground ordinance of 1881. The result has been the multiplication of small isolated plants and the formation of the nine small central station plants bought out by this company. None of these plants made any money. It was impossible for them to do so, operating underground and upon so small a scale. No streets have ever been lighted by electricity here, in fact the whole industry is in a very backward condition, and is likely to remain so, except in the most densely crowded portion of the city, unless some arrangement can be made with the city authorities for overhead wires. The city is trying an experiment of its own, in lighting Chicago River, which will, I am confident, demonstrate the truth of the foregoing statement; and in the course of a year I hope that our city fathers will permit overhead lines in many

places where public convenience demands electric lights, while underground construction would forbid it."

At Milwaukee, Wis., three systems have been tried and abandoned, *i.e.*, a wooden trough, plain and tarred iron pipe, and grooved wood. A fourth, consisting of tile conduits, with a heavily insulated, but not lead covered, cable has recently been introduced, and is now being tested. The company doubts whether it will stand the trying spring season. At Detroit, the Thomson-Houston Company employed a cable of the most expensive and approved character in the Dorsett conduit, and the mechanical work was of the best quality. While the cable was new the results were fair, though loss by seepage rendered it impossible to produce normal lights. It was found impossible to operate telephone wires in the same or adjacent pipes. The company soon abandoned the system, and when its cable was removed it was found the insulation had so rotted or softened that considerable lengths of the wire in many places were stripped bare.

With the alternating system some wires have been undergrounded in Springfield, Mass., and in Denver, Colorado, and a small amount in Pittsburgh, but the voltage is only half that of the arc light systems, and even with this low voltage the lead-covered cables have not been in use long enough to determine the question of their success. The difficulty from explosions of gas has been met with many times at Chicago, New York, and elsewhere, as well as at Philadelphia, and seems insurmountable where gas is employed. At New York men have been suffocated in the main holes, and in the Western Union Building the escape of gas from their conduits has been almost unbearable. At Detroit an explosion took place in October last in the middle of the night, in a fire-alarm conduit with closed manholes, and in which no wire had ever yet been placed. It doubtless occured through the admixture of illuminating gas and sewer-gas, or other exhalations, in proportions, to explode spontaneously. The manhole cover was thrown high into the air, the street torn up, and the paving blocks scattered over a distance of eighty feet or more. The problem of undergrounding arc light wires is by no means solved, but appears to-day to be further than ever from solution, owing to the utter failure of systems which apparently had all the elements to insure success. In this emergency, municipal bodies must suit their action to the fact. To legislate arc light wires beneath the ground when no practical system is presented for accomplishing that end, is actually and literally to bury the system. When a city is so sanguine of the soundness of its judgment, the remedy would seem to be for the city to provide conduits and the necessary cables, guarantee their success, and then compel lighting companies to rent their lines at a proper figure, or failing so to do to quit the field. Summary action on any other basis is incompatible with that justice and equity which it is the inherent right of every person to demand and receive. Any other course is to discourage enterprise and to ruthlessly impair or destroy capital invested in good faith. The difficulty usually met with is a peculiar and unreasonable one. Municipal and legislative bodies view with suspicion the lighting companies, their officers, stockholders, and everybody connected with them. It seems to be assumed that because the companies make a certain showing of facts the facts must necessarily be exactly the contrary, and they legislate accordingly. Thus at Detroit, in opposition to letters produced by the lighting company, alleging repeated trials and failures at Washington, Philadelphia and Chicago, the then mayor, unquestionably in good faith, reported to the council as the result of his personal investigation upon the spot, that no electric light wires had ever been buried in the city of Washington, a most glaring error; yet this was followed by a report of the committee and unanimously adopted by the council, that underground systems of electric arc light wires were entirely practicable and were in successful use at Washington, New York, Philadelphia and elsewhere. At Cleveland recently the strongest argument in the underground struggle advanced by the city was that the wires of the Thomson-Houston Company, of Detroit, were operating underground in the Dorsett systems, whereas not a foot of arc light wire is underground in Detroit. To combat this unreasonable and unreasoning prejudice, the question whether any system yet discovered is practical and sufficient for the pu should be thoroughly and exhaustively examined, an elaborate report made and published with full data which the conclusions are reached. This should be by a board of competent and eminent men of nat repute entirely disconnected from the electrical bus such as could be gathered from the scientific chairs c largest colleges and polytechnic institutes, and it would with the interested companies of this association to c bute from their own funds, or to influence the nece contribution by the councils of their respective cities, t the necessary expenses of such an inquiry.

COMPANIES' MEETINGS.

THE MAXIM-WESTON ELECTRIC COMPANY.

A meeting of the shareholders of the Maxim-Weston E Company, Limited, took place on Wednesday, the 28th ult., City Terminus Hotel, Mr. Hugh Watt, M.P., in the chair.

The notice calling the meeting was read by the **Secretar** John Wright), and the report of the directors was taken as read

The **Chairman,** in the course of a long address, said: The holders form now an almost wholly new body from that which when we took office. The new board undertook to reconstru Company and to place it on a proper financial basis, but h conception of the difficulties that were before them, or little aid they would receive from the shareholders. Whe the directors, took office, the fact was disclosed that the Co was virtually insolvent, with no profitable contracts in but with unprofitable ones, to fulfil which would entail a over £10,000 per annum. Hence there appeared before it or near prospect of liquidation. The list of shareholders at th consisted of less than 1,000, and so little faith had those gen in the future of electric lighting (the feverish period of electric ing had passed away), that to prevent the Company from into liquidation only £550 was subscribed. It was, therefore, sary for the directors to put their hands in their pockets, and the assistance of their friends, to find capital to carry o Company. I do not want to say where the money came or who found it, because that would involve a personal refe but sufficient was forthcoming to wipe off the debts, to of useless warehouses and unprofitable City contracts, and pla Company upon a sound financial basis. That was abou years ago, and during that period the original sharehold those who have since come in, have subscribed a certain amo capital; but the bulk of that which has enabled us to take new to lay down adequate plant, and to carry on the business, ha found by the board, with the exception of some £4,000 or subscribed by the shareholders to date. The dividends paid present board have been twice that amount, so that I think the a at all events is pretty square as far as the existing shareholders a cerned. You may say that has reference to the end of 1886, an is true. With regard to 1887, you probably expected a dend. I also expected one, and up to November had reason to expect one. At that date we had entered int visional contracts entitling me to assume that afte payment of a dividend of 5 per cent. there would considerable balance remaining, but three large contracts fell th which left us with a deficiency of about £3,000 of profits. No occasion to mourn that more than I have, because it means a loss upon my large holding. At the same time during the past have carried out an amount of business greatly in excess of years, but we have met with opposition we could not foresee— from persons who had sold £1 worth of goods for less than have given a vast amount of attention to the Company in my as chairman, but that position I am ready to resign into your should you wish me to do so. With regard to the accounts Mr. will read you the report of the auditors.

The report was then read.

The **Chairman** (continuing): The view of the auditors is in and calculated to place impartial data before the shareholders. regard to no provision being made for bad and doubtful debts— the receipt of the auditors' letter the directors decided to tran entire balance of profit to a reserve fund. To the reserve acoun is a sum placed against bad and doubtful debts from the Lighting Power and Generator Company, which sum was abso to the period ending 1885. Last year we passed no sum to th of reserve account, because we did not think there was any pro any such sum requiring to be so passed. The shareholders were for a dividend, and had we passed a sum to this account end of 1886 we should not be able to pay that dividend. Th holders got the advantage, but this year, looking at th of the case, the directors decided upon passing the amount o to the credit of this reserve account, which was absorbed in d to and including 1885. We found that the manufacture of the dynamos, sufficient to run 500 lights, would necessitate puttin other machinery. Since 1883 the accounts have been prepa looked after by Mr. Alabaster, late of the firm of Messrs Waterhouse, and Co., and I have had nothing to do with the I told him that the item of £1,555 ought to be £650 mor Alabaster did not agree with me, and therefore the acco printed as you see them. There is a slight discrepancy in the sheet, owing to the dividend last paid having absorbed £25 m

we calculated. The additional plant put down at the factory enables us to manufacture Maxim-Weston and Watt dynamos. I agree with Mr. Dever that it is desirable to charge nothing more to patents; but an electric company is not like a butter business, where you sell your product and pocket your profit. Nor do I agree with a noble lord, the chairman of another company, in assuming that systems are now perfected. In my opinion, no system is perfected. We are proceeding on our own lines, and believe we are right. However desirable it may be not to add anything to patents account, as long as the present competition is going on, and also monthly improvements are being made, we cannot stand still. We must keep abreast with the times, and we must meet the formidable competition we experience on every hand. The expenditure has been entailed entirely upon Maxim-Weston patents. We were very much inconvenienced by the fire in New York, which deprived us of incandescent lamps, for the supply of which the Company was originally formed. We have been compelled to tender for Swan lamps. We are very much indebted to our manager for his great services, and also to our secretary (Mr. Wright) for his indefatigable exertions. Our manager is a competent electrician; he experiments continually, and has done for us service worth five times his salary. I found on close examination that our incandescent lamps cost us 7s. 6d. each, and we made experiments which reduced the cost to something like 3s. 9d. That led to the dismissal of a large number of supernumeraries; but we could not get over the difficulty of durability. I thought the best way was to cease to manufacture ourselves and to rely upon the American company. In the United States £30,000,000 or £40,000,000 sterling is invested in electric lighting. We now know the new lamps are good, and compare favourably with anything that can be produced in America. We have had no litigation with the Edison-Swan Company, and we do not expect any because we have a perfectly sound patent that we can sustain. We have not succeeded in obtaining as many orders simply for the reason I mentioned in regard to our competitors, and in many cases to a loss of contracts. It is useless attempting to carry on an electric lighting company unless you go on making improvements. If you decide to stop improvements I resign my seat, because I despair of such a company, and know that it will soon be out of the running. We are in a better position than the American company, and can turn out plant equivalent in candle-power to the American plant at less cost. One cause of that is the protective system in American, which places them at a disadvantage of nearly 30 per cent. The asset of the Sun Company—the shares of which we got for nothing—I am told is worth £2,000, and not the small amount set down in the balance-sheet. The sundry debtors includes an amount largely owing by the Chancellor of the Exchequer, who is very loth to part with money. It is a matter of regret to the directors that the shareholders have not applied, but to a trifling amount, for the last issue of shares. The money would have been of great service to the Company. I took my full proportion, and from time to time the directors have done their duty in relation to the Company. The new Watt patents necessitated a good deal of outlay. They were called so out of courtesy to me; but others were associated with me in them, some of whom I had to buy out. I have expended last year from £2,000 to £3,000. These patents do not belong to this Company. It was thought to buy them, but the directors resolved to leave it an open question; but I have secured the manufacturing patents to this Company on a royalty. If of no value, you pay nothing for them; if they are of value, a very large proportion of the profit comes to this Company. There has been no cost in the matter to the Company. I believe we will secure for these patents enormous sales, and at an early date. We shall be able to compete for Government business at an immense saving upon anything that has taken place previously. I think this Company is well in the van with regard to electric lighting. In conclusion, I have no hesitation in saying that the position of this Company to-day is better than ever it was. The chairman concluded by moving the adoption of the report.

Mr. George Howell, M.P., seconded the motion.

Mr. Louis Swaby proposed as an amendment: "That the report and accounts should not be passed, but that a committee of enquiry should be appointed to investigate them." He denied that he had had anything to do with drawing up the report, although he was a director, and he contended that Mr. Howell had been improperly elected. He went on to read voluminous correspondence between himself and Mr. Watt, including a letter marked private, to which objection was taken.

A long discussion ensued and ultimately a committee was appointed to investigate the Company's affairs and reports to a general meeting, which was then and there fixed for April 25.

The **Chairman** quite approved of the committee, and he was prepared to fully meet every one of Mr. Swaby's statements.

A vote of thanks to the chairman closed the proceedings.

PROVISIONAL PATENTS, 1888.

MARCH 23.

4453. **Improvements in railway signalling, which he names "Shakeshaft's automatic electric-railway signal."** James Shakeshaft, Ashton, Towcester, Northamptonshire.

4456. **An improved method of administering galvanic currents for curative purposes.** Augustus Collingridge, 97, Newgate-street, London, E.C.

4474. **Improvements in structures for supporting electric and other conduits, and for facilitating access to buildings.** Bernhard Dukes, 226, High Holborn, Middlesex. (Maurice J. Hart, United States.)

4489. **An improvement in holders for electric glow lamps.** Edward Frederick Hermann Heinrich Lauckert and Ernst Hermann Haensel, 28, Southampton-buildings, Chancery-lane.

MARCH 24.

4523. **Telegraphic and telephonic apparatus, part being applicable to other electrical purposes,** James Kelman, 14, Young-street, Quay-street, Manchester.

4524. **Improvements in portable galvanic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

4559. **Improvements in electric arc lamps.** Frederic de Wolffers, 3, Deronda-road, Herne-hill, London, S.E.

4561. **An improved battery jar.** Charles Alva Brown, Somerset Chambers, 151, Strand, London.

MARCH 26.

4568. **Improvements in or relating to conductors for electrical and acoustic purposes.** Samuel Williams, 8, Rutland-place, Newport, Monmouthshire.

4579. **A new or improved electrical apparatus for combining an electrical alarum with the ordinary mechanical alarum.** James Joseph Dillon, 10, Leinster-street, Dublin.

4593. **Improvements in electrical batteries and methods of closing the same.** Frederick Lawrence Rawson, 11, Queen Victoria-street, London, E.C., and William White, 40, Ranelagh-road, Willesden Junction.

4626. **Improvements in the electrolytic production of metals.** Carl Hoepfner, 28, Southampton-buildings, London, W.C.

4627. **An improved method of using incandescent electric lights.** Charles Wells and Frederick J. Goad, 22, Southampton-buildings, Chancery-lane, W.C.

MARCH 27.

4659. **Improvements in apparatus for making and breaking electrical circuits in connection with call or alarm boxes and recording the same automatically on dials.** Frederick Thomas Schmidt, Sunbridge Chambers, Bradford, Yorkshire.

4673. **Improvements in and connected with apparatus for the generation and utilization of electric currents.** Philip Middleton Justice, 55 and 56, Chancery-lane, Middlesex. (Charles Heisler, United States.) (Complete specification.)

MARCH 28.

18,036. **A new or improved coin-operated induction coil.** Wm. Riley Pope, 70, Market-street, Manchester. Received 28th March, 1888, antedated 31st August, A.D., 1887, under International Convention.

4759. **Improvements in and relating to telephonic apparatus.** Henry Harris Lake, 45, Southampton-buildings, London. (International Dudley Signal Co., United States).

4764. **Improvements in portable galvanic and electro-magnetic batteries for medical purposes.** Arthur Lake Fry, 34, Southampton-buildings, London, W.C.

MARCH 29.

4804. **A new switching arrangement for electric signalling, telephones, telegraphs, &c., by means of which any number of instruments may be worked on one single line, one with the other.** Edward Jesse Piper, Tufton-place, Northiam, Sussex.

4819. **Battery for general electro-medical use, or as electrical dumbbells, Indian clubs, and the like, for muscular exercise with electrical current of any desired strength during such exercise.** William George Johnson, 58, New Bond-street, Middlesex.

COMPLETE SPECIFICATIONS ACCEPTED.

MARCH 21, 1887.

4220. **Improvements in instruments for measuring electric currents.** John William King, 13, St. John's-square, London, E.C.

MARCH 25, 1887.

4447. **A new or improved apparatus for measuring, indicating, and recording currents of electricity.** Paul Bedford Elwell, 70, Market-street, Manchester.

MARCH 31, 1887.

4832. **Improvements in the manufacture and construction of carbon "plates" or electrodes for use in primary batteries and for electro-metallurgical, electrolytical, and other electrical purposes.** Henry Liepmann, of The Liepmann Carbon Co. (Limited), 77, Chancery-lane, Middlesex.

FEBRUARY 29, 1888.

3097. **An improvement in holding the plates of secondary voltaic batteries.** Bernard Mervyn Drake and John Marshall Gorham, 28, Southampton-buildings, Chancery-lane, London, W.C.

SPECIFICATIONS PUBLISHED.

1887.

4225. **Electricity meters.** G. Hookham. 1s. 1d.
5562. **Generating, &c., electricity.** W. Maxwell. 6d.
5709. **Dynamo-electric machines.** A. I. Gravier. 8d.
5867. **Secondary batteries.** W. Kingsland. 8d.
6168. **Telephones.** H. F. Jackson. 8d.
6294. **Electrolytic treatment of zinc, &c.** A. Watt. 6d.
17,704. **Telephones.** A. C. Herts. 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	$3\frac{1}{4}$
12 Feb.	2/0	— fully paid	5	$4\frac{1}{4}$
15 Feb.	10/0	Anglo-American	100	39
15 Feb.	20/0	— Pref.	100	65
12 Feb., 85...	5/0	— Def.	100	$14\frac{3}{8}$
29 Dec.........	3/0	Brazilian Submarine.........	10	$12\frac{3}{16}$
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
15 Feb.	8/0	Cuba	10	$12\frac{3}{4}$
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	$3\frac{3}{4}$
18 Oct.	5/0	— 10% Pref.	10	$9\frac{1}{2}$
14 Oct.	2/0	Direct United States	20	$8\frac{5}{8}$
12 Jan.	2/6	Eastern	10	$11\frac{7}{8}$
12 Jan.	3/0	— 6% Pref.	10	$15\frac{3}{8}$
1 Feb	5%	— 5%, 1899	100	$105\frac{1}{2}$
28 Oct.	4%	— 4% Deb. Stock	100	108
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	$12\frac{7}{8}$
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	$104\frac{1}{2}$
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	$104\frac{1}{2}$
12 Jan.	5/9	German Union...............	10	$9\frac{1}{4}$
27 Jan.	1/6	Globe Telegraph Trust......	10	6
27 Jan.	3/0	— 6% Pref.	10	$13\frac{13}{16}$
3 Jan.	5/0	Great Northern...............	10	$14\frac{1}{4}$

Dividend.		Name.	Paid.	Price. Wednesday.
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105x
28 July	10/0	India Rubber, G. P. & Tel.	10	$16\frac{1}{2}$
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
16 March ...	5%	Maxim Weston	1	3-16
15 May	5%	Oriental Telephone	11	$\frac{1}{2}$
14 Oct.	4/0	Reuter's	8	$8\frac{1}{4}$
......	...	Swan United	$3\frac{1}{2}$	$2\frac{5}{16}$
15 Feb.	$15\frac{1}{2}$%	Submarine	100	142
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	$39\frac{1}{2}$
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	$14\frac{15}{16}$
......	...	West African	10	5
1 March ...	5%	— 5% Debs.	100	92
29 Dec.........	6/0	West Coast of America ...	10	$5\frac{5}{8}$
31 Dec.	8%	— 8% Debs.	100	116
14 Oct.	3/9	Western and Brazilian	15	$9\frac{3}{4}$
14 Oct.	3/9	— Preferred	$7\frac{1}{2}$	$6\frac{5}{8}$
......	...	— Deferred..................	$7\frac{1}{2}$	$3\frac{1}{4}$
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	105
......	...	West India and Panama ...	10	13-16
30 Nov.	...	— 6% 1st Pref.	10	$10\frac{1}{2}$
13 May, '80...	...	— 6% 2nd Pref.	10	$6\frac{1}{2}$
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Sept.	6%	— 6% Sterling	100	101x

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. March 23...	£5,094	...
Cuba Submarine	M. of Feb. ...	3,600	+ £591
Direct Spanish....................	M. of Feb. ...	1,858	+ 235
— United States	None	Published.	...
Eastern..............................	M. of Feb. ...	51,261	+ 4,361

Name.	Ending.	Amount.	Inc. or Dec.
Eastern Extension	M. of Feb. ...	£38,795	+ £3,242
Great Northern	M. of Feb. ...	20,400	...
Submarine	None	Published.	
West Coast of America	M. of Feb. ...	4,625	...
Western and Brazilian	W. March 23...	4,179	...
West India and Panama	F. March 15 ...	3,333	+ 55

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

West Coast of America Telegraph Company.—The traffic receipts of the West Coast of America Telegraph Company for March were £4,175.

Brazilian Submarine Company.—The traffic receipts of the Brazilian Submarine Telegraph Company (Limited), for the week ended March 30 amounted to £4,315.

Direct Spanish Telegraph Company.—The estimated traffic receipts of the Direct Spanish Telegraph Company for the month of March are £1,900, against £1,863 for the corresponding period of last year.

Dissolution of Partnership.—Messrs. Heenan and Froude, of Newton Heath Ironworks, Newton Heath, Manchester, have dissolved partnership. The business will, however, be carried on by Mr. Richard H. Heenan.

Telephone Company of Austria.—The directors of the Telephone Company of Austria have declared an interim dividend at the rate of 6 per cent. per annum on their preference shares for the six months ending 31st ult., payable, less income-tax, on and after April 9th.

Oriental Telephone Company.—The directors of the Oriental Telephone Company have decided to recommend a dividend for the year ending December 31 last of $2\frac{1}{2}$ per cent., free of income tax, on the paid-up capital of the Company other than the vendor's shares.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the week ended March 30, after deducting the "fifth" of the gross receipts payable to the London Platino Brazilian Telegraph Company (Limited), were £3,491.

West Indian and Panama Telegraph Company.—The estimated traffic receipts of the West Indian and Panama Telegraph Company for the half month ended March 31, are £3,703, as compared with £3,430 in the corresponding period of 1887. The December receipts, estimated at £5,577, realised £5,612.

The Julien Electric Company (Limited).—A new company is registered under this title. Capital, £1,000,000, in 10,000 shares of £10 each. The first subscribers are:—

A. W. Ripping, 9, Woodville-road, Mildmay-road, N.
R. R. P. Braithwaite, 56, Osnaburgh-street, Regent's Park.
A. F. Stokes, 5, Birchin-lane, E.C.
T. B. Weare, 50, Devonshire-chambers, Bishopsgate-street, E.C.
A. Barton, 30, Malvern-road, Dalston.
R. Gordon, Acacia-grove, New Malden, Surrey.
A. G. Pavill, 2, Cavendish-terrace, Frant-road, Thornton Heath.

Companies of the Month.—The following Electrical Companies have been registered during the month of March:—

Charles L. Baker and Co. (£5 shares)	£25,000
Electrical Works Construction and Maintenance Co. (£1 shares)...	2,000
St. James's and Pall Mall Electric Light (£5 and £1 shares)	100,000
Bournemouth Electric Light and Power Co. (£5 shares).........	4,000
Gulcher (New) Electric Light and Power Co. (£1 shares)	70,000
Exeter Electric Light (£10 shares).......................................	20,000
Julien Electric Co. (£10 shares)	100,000
Schanschieff Electric Light and Power Co. (£5 shares)	200,000

NOTES.

Meteorological Society.—At the meeting to be held on Wednesday, the 18th inst., Prof. A. S. Herschel will read a paper on "Lightning in Snowstorms."

Chez Bignon.—The celebrated restaurant in the Avenue de l'Opéra, so dear in every sense to epicures of all nationalities, is now lighted by incandescence lamps.

Union Bank Installation.—We understand that Messrs. B. Verity and Sons were the contractors for the whole of this installation, and not merely for the fittings.

Edinburgh Public Library.—Tenders are invited by the Edinburgh Municipality for the electric lighting of this library. Further particulars will be found in our advertising columns.

The Electric Light in Russia.—The theatres at Odessa and Riga have been electrically lighted by Ganz and Co., of Buda-Pesth. The central station supplying the former town is more that a kilometre and a half distant from it.

Spain.—The Government is putting up to auction the right of constructing and working telephonic systems at Alcoy (province of Alicante) and at Murcia. The former concessions will be disposed of on the 27th inst., and the latter on the 13th of June.

Poplar Union.—The Guardians of the above Union invite offers for the repair and maintenance of the electric bell system at the workhouse. Application is to be made to the master of the workhouse, High-street, Poplar, who will supply form of tender.

Barnet.—A draft contract has been submitted to the Barnet Local Board, by Messrs. Joel and Co., for electric lighting. After a discussion of the subject at the last meeting of the Board, and the requirement of a provisional order, the question was adjourned to a future meeting of the Board.

Verona.—The local company formed to establish a central station for electric lighting having failed to carry this project into effect, power was given to the gas company, at a general meeting of its shareholders, to take up the question of lighting by electricity, and eventually to carry the requisite work into effect.

Halifax-Bermuda Cable.—As will be seen from our advertising columns, the Postmaster-General invites tenders for laying, maintaining and working a telegraph cable from Halifax (Nova Scotia) to Bermuda. The line will be subsidised by Government, whose liability or responsibility in regard to it is limited to the payment of the subsidy.

The Electric Light in Austria.—Messrs. Siemens and Co., of Berlin, have undertaken the work of establishing at Quortitz a central station, disposing of 500 h.-p., and supplying 4,500 lamps. The same firm have installed at Salzburg a central station, working 300 incandescence and 26 arc lamps by means of three dynamos. The price per incandescence lamp per hour is 9·2 centimes (4 kreuzers).

The Telephone at Martinique.—On the 16th prox. a concession for the working of the subventioned service of electrical communication in the interior of the colony will be disposed of by auction. The system will consist: 1st, of a telegraph line between Fort-de-France and Saint-Pierre, already established, and 2nd, of a network of telephonic lines between all the communes in the island which has yet to be constructed.

An Insulation Breakdown.—After the recent snowstorm at Pittsburg, large quantities of salt were used to melt the snow on an electric tramway with underground conducting wire. The resulting solution of salt, having saturated the wooden conducts in which the conductor was laid, destroyed the insulation of the line, which was worked under an E.M.F. of 500 volts, and the whole of the woodwork was rendered useless.

Rheims.—The local company for private electric lighting has been dissolved, and, as in several other instances, the work has been taken up by the gas company. At a general meeting of the shareholders of the company, full powers were given to the directors for continuing the negotiations with the town authorities on the subject of electric lighting, and provision was made for the expense to be incurred under this heading.

High Ratio of Power to Weight.—According to *Cosmos*, M. Trouvé has constructed a minute electric motor, weighing 90 grammes, and yielding a power of two kilogrammetres (about 14·5 foot-pound) per sec. Under an E.M.F. of 14 volts (*Cosmos* spells it *wolts*) this little machine, provided with a fan, will raise its own weight—*i.e.*, itself. At this rate, a motor developing one horse-power would weigh little more than three kilos.

Clermont-Ferrant.—The gas company at this town has been more successful in electric lighting than has the competing local company, which until recently carried on the lighting of some private establishments. The town authorities gave the preference to the former in regard to the work of illuminating the theatre, and the gas company has expended from 30,000 to 40,000fr. in carrying out the installation, which has been a success.

Sulphur.—In its ordinary condition sulphur is one of the best insulators, *i.e.*, one of the worst conductors known. M. Duter, in some experiments at the Sorbonne Laboratory, has, however, shown that, when raised to its boiling point (about 836deg. F.), sulphur is capable of transmitting an appreciable current of electricity. With electrodes of gold, connected to a battery of Leyden jars, a current was obtained having the mean value of $\frac{1}{8000}$ ampere.

Christchurch (New Zealand).—The Council of Christchurch, New Zealand, invite tenders for lighting the city by electricity, in accordance with the specification and conditions to be seen at the office of the Agent-General for New Zealand, 7, Westminster-chambers, Victoria-street, London. Tenders to be sent direct to the Christchurch City Council, New Zealand, to arrive by the 1st July. Mr. F. T. Haskins is town clerk at the City Council Office.

Bradford.—At the meeting of the Council, held on the 10th inst., Ald. Priestman (chairman of the Gas Committee) stated that the specifications for the installation of the electric light had been prepared, and he expected tenders to be received by the 25th inst. The specifications had been very carefully prepared after making enquiries into the systems of electric lighting adopted elsewhere, so that Bradford might have the advantage of the best system.

Bristol.—The Bristol Cathedral is to be lit by electricity, and it is proposed to use such light at the grand evening service and production of Handel's oratorio, "Israel in Egypt," on Friday, June 8th, in celebration of the completion of the western towers. When the Jubilee services on a similar scale were given in the cathedral, the rows of gas jets necessary to give light to the 500 members of the

choir enclosed them with lines of such intense heat that some of the closely-wedged choir had to retire.

The Society's Fire Rules.—We have received a copy of the Society of Telegraph-Engineers' rules and regulations recommended for the prevention of fire risks from electric lighting, dated April, 1888. Our opinion as to the advisability of multiplying "rules" is well known. If satisfactory, the different rules must be approximately the same in tenour—if, indeed, they are not in their verbal rendering. We regret that some way has not been found to bring the conflicting interests into agreement.

"Montagnes Russes."—The Thomson-Houston Company has just carried out its first installation of electric lighting in Paris. It comprises about thirty arc lamps for the new establishment of *montagnes russes* at the Boulevard des Capucines. The popular though desultory system of locomotion known by this name is analogous to the toboggan and switchback railway, the excursionist entering a car which speeds with giddy rapidity along smooth rails for a furlong or so. The electric light in such establishments is *de rigeur*.

The Fire at the Hotel de Lucerne.—The disastrous fire which destroyed the Gutsch Hotel had been attributed to a Zipernowski transformer; but it now appears that the damaging accusation brought against one of the systems of electric lighting was altogether unfounded. The transformers, which were duly provided with fusible cut-outs, are proved to have been in working order whilst the fire was actually proceeding; and the presence on the roof of the hotel of a working plumber with lighted brazier appears to be the most probable cause of the conflagration.

The Electric Light at Perpignan.—The Municipality of this town are in treaty with the electric lighting company recently established there by M. Lamy for the lighting of the theatre, and for the distribution of the current to private establishments. The duration of the proposed concession is 30 years, and the price to be charged for public illumination is 2 centimes per hour per lamp of 16 c.-p., or 1 centime per hour per lamp of 10 c.-p. Certain fines are imposed in case of shortcomings in the due performance of the contract on the part of the company.

The Electric Light in Textile Manufactories.—M. Krœttlinger, in the "Centralblatt für Elektrolechnik," points out that incandescence lighting has, with great advantage, superseded petroleum in a lace manufactory near Carlsbad, where artificial illumination is sometimes necessary for as many as eighteen hours per diem. The dynamo machine employed is from the Viennese firm of the same name as that above mentioned, and supplies 30 amperes, at a potential of 100 volts, when making 950 revolutions per minute. Another, and larger, installation is at the silkworks of Messrs. J. Adensanser and Co., at Vienna.

The Lewis Cable.—On Tuesday last, in the House of Commons, Dr. M'Donald asked the Postmaster-General when it was his intention to have the telegraph cable between Lewis and the mainland, which had been out of order for several weeks, repaired; and whether, having regard to the large fishing interests of the island, which were mainly dependent for the sale of fish on telegraphic intelligence, he intended to lay a new cable instead of that now out of order. Mr. Raikes stated, in reply to the hon. member, that the cable ship belonging to the Post Office is at the present moment engaged in the repair of the Stornoway cable.

The Electric Light in Theatres.—An incident has occurred at the Madrid circus which practically illustrates the known fact that when carelessness and the neglect of obvious precautions come into play, the electric light, whilst safeguarding against the manifold dangers of gas, may actually be the means of producing a conflagration on its own account. The current traversing one of the conducting wires was so unduly strong as to set fire to its covering and to some articles in proximity to it. Happily the alarm occasioned quickly subsided, and the damage was but of small importance.

The Electric Light in Theatres.—At a recent meeting in Paris of the Superior Committee on Theatres, under the presidency of the prefect of police, it was decided that the supplementary lamps (*lampes de secours*) might be supplied by accumulators, and worked in two circuits only. On the motion of M. Duynesnel, who urged that every facility should be afforded to theatres in adopting the electric light with a view to the safety of the public, the committee recommended that an exceptional permission should be granted to them by the Prefect of the Seine to make use of the street subways in laying the mains for supplying electrical power from external central stations.

Protection of Wires.—Electric light engineers have passed by, or have not sufficiently recognised, the value of iron piping glazed in the interior for carrying their leads. If well done, the glaze is a good insulator, and, therefore, it is probable a cheaper covered wire could be used than is usually the case. We have before us a specimen of such iron piping, ⅝in. clear internal diameter, made by John Spencer, Globe Tube Works, Wednesbury, sent us at our request, as the matter had been discussed among several electrical engineers with the result of obtaining a general opinion that the material would be useful. Of course the pipes can be made to any other size that may be required. We have no information as to how the price of such piping would compare with the present methods.

The E.P.S. Accumulator in France.—Since the failure of the "Frenck" and "Metropolitan" Companies in 1884, the manufacture of Faure-Sellon Volckmar had been discontinued. Quite recently, however, Messrs. Philippart Bros. have acquired the French patents for this battery and for the newer type of cell known as the E.P.S., and are about to commence the manufacture of this accumulator at their works, which they have established in the old Siemens' workshops in Paris. According to the *Bulletin International de l'Electricité*, Messrs. Philippart have caused the seizure in Paris of accumulators of all forms and patterns, and have commenced actions against a certain number of manufacturers. The result of these proceedings is looked forward to with a considerable amount of interest.

The Paris Municipal Council.—"According to its own showing," says the *Bulletin International de l'Electricité*, "the Council has done two things that it was particularly anxious to avoid doing: it has established a practical monopoly, and it has acted adversely to the interests of the working classes." This conclusion is based upon the decisions arrived at by the Council, firstly, in relation to the granting of concessions applicable to segments of a circle extending from the centre of the city to the fortifications, and, secondly, in stipulating for the use of accumulators by concessionaires with a view to the employment of a minimum number of *ouvriers* at night. "Only the Rothschild and Edison companies," according to our contem-

porary, "could undertake the establishment of central stations having their works at Villette and at Ivry."

The Radio Micrometer.—This instrument is an extremely delicate form of thermopile, consisting of a square frame made of one turn of one square centimeter, of which three sides are thin copper wire, and the fourth is a compound bar of antimony and bismuth, each piece being 5 by 5 by ⅛ mm., soldered edge to edge. This frame is supported by a thin rod, to which is fastened a mirror, and the whole is hung by a torsion fibre, so that the frame is in the field produced by a powerful magnet with suitable pole pieces. When radiant energy falls on the centre of the bar the frame is deflected, and the amount of the deflection measures the energy. Adopting suitable dimensions, and using a very strong field, an instrument may be made capable of showing a change of temperature of the junction of one thousand-millionth of a degree of heat.

The Krebs Electric Motor.—A motor to be worked by accumulators, intended for a submarine boat which is being constructed by M. Zédé, has recently been completed by M. Krebs, who has laid before the *Académie des Sciences* the results of some experiments which have been carried out with it on *terra firma*. The machine weighs 2,000 kilos, and will, it is stated, give a power of 52 *chevaux vapeur* when worked with a current of 200 amperes under a difference of potentials at the terminals of 192 volts. (The theoretical value of the watts is under 52 horse-power; but it must be remembered that the *force de cheval* is equivalent to 736 watts only, instead of 746). The current is supplied by 564 accumulators on the Commelin, Desmasure, and Baillehache system, in which an alkaline electrolyte is employed. The total weight of these accumulators is 9,840 kilos. Arrangements have been made for connecting up the accumulators in four different ways, in order to vary the expenditure of power. The results obtained are said to verify the anticipations of the inventor.

Arthur-street East Extension.—The engineer to the Commissioners of Sewers (Colonel Haywood) refers in his annual report to the Arthur-street East extension. This street extension commences on the eastern side of the Monument, and is carried by an easy curve to the southern end of St. Mary-at-Hill, where it joins Lower Thames-street opposite to Billingsgate Market. Its length is 454ft., its width 50ft., the roadway is 33ft. wide, the footways on either side 8ft. 6in. wide, and its gradients vary from 1 in 34 to 1 in 39. At its junction with Lower Thames-street is an open space about 140ft. long and 80ft. wide. Beneath the centre of the street is a subway for gas, water, and other pipes, semicircular in form, 12ft. wide and 7ft. 6in. high. A paved footway with iron tram rails is laid throughout the subway, thus enabling pipes and materials to be readily moved by trolleys. Sleeper walls are built on each side throughout its length to support the pipes; cast-iron brackets project from the wall on each side, about 5ft. above the floor-line, for the same purpose, and provision is made for the carrying telegraph and telephone wires by hooks fixed in the crown of the subway arch.

Prices in America.—New Haven pays for 2,000 candle-power lamps, running every night and all night, 50 cents (say 2s.) per night, or 182.50dols. (£36. 10s.) each per year. Middletown pays for 2,000 candle-power lights running every night until 11:30 p.m. 100dols. (£20) each a year; for 2,000 candle-power lights running 20 days a month 75dols. (£15) each a year, and 35 cents each per night over 20 nights a month, all lights running till 11:30 p.m. Waterbury pays for 2,000 candle-power lights running 312 nights until 1 a.m. 117dols. (£23. 8s.) each a year, and for 1,200 candle-power lights running the same hours and same number of nights 78dols. (£15 12s.) each a year. Bridgeport pays for 2,000 candle-power lights running every night all night 50 cents a night, or 182dols. 50 cents (£36 10s.) each a year. Meriden pays for every night in the year, and running until 1 a.m., 150dols. (£30) each a year. Hartford pays under present contract for 337 nights, running all night, 142dols. 51 cents (£28 10s.) for each light. Under the new contract made by the street board, it pays 117dols. 94 cents (£29 8s. 1d.) each, and gets under this new contract, as also under the present contract, 2,000 candle-power lights running all night for 337 nights, and 1,200 candle-power lights at a corresponding price, or at 78dols. 63 cents (£15 14s. 1d.) each a year.

Incandescence Lamps.—In reference to the views of Mr. Husted, quoted in a note under this heading in our last issue, the *Electrical World* recalls the experiment of Prof. Quincke, who exhausted a glass tube and weighed it at intervals during many years without being able to detect the slightest difference in its weight by the most delicate balance. This result may be accepted as conclusive proof that no air had obtained admission to the tube in question. The contention that in the case of incandescence lamps air enters through the "pores" of the glass when the latter becomes heated, appears improbable, and has not been supported by any direct experiment. Still, it is known that hollow vessels of comparatively thick metal, when under pressure and heated, allow the passage of liquid; and it is possible that thin glass, especially of a certain quality, may, when heated, allow the passage of air. It is beyond question that, under ordinary conditions, air may find an entrance at the junction between glass and a platinum wire embedded in the same. The constituents of air would no doubt enter into combination with the carbon of the heated filament; but it is questionable whether it would have any effect in "vaporising" that element. There is really no evidence, in fact, that the blackening of the globes of incandescence lamps is due to a defective vacuum. The true cause of this effect is a question of great interest and importance, as is everything relating to the effective life of such lamps.

Porous Electrodes.—In connection with the accumulator, with a negative element (anode in charging) of porous copper, and with an alkaline electrolyte, devised by Messrs. Commelin, Demasures, and Baillehache, a series of experiments have been carried out by M. Bandsept, of Brussels, with a view to determine the degree of porosity most favourable to the storage capacity of the element, due regard being paid to its mechanical permanency. The point is one of considerable practical interest, since it relates to the conditions under which a storage capacity of 8,200 kilogrammetres per kilogram of battery (26,896ft. lb. per lb.) has already been obtained, and under which this may possibly be even augmented. The copper elements in question are obtained by the powerful compression of the metal in the condition of powder or sponge; but this compression must not exceed a certain limit, beyond which the material becomes analogous to the cast metal. On the other hand, from the point of view of the electrical conductivity of the porous metal, as well as from that of its mechanical properties, it is obvious that the compression

must attain also a certain minimum limit. The determination of the maximum and minimum limits of compression may probably result from the experiments in question. M. Bandsept has experimented with pulverulent deposits electrolytically obtained on surfaces of metal, with the result that mechanical pressure may sometimes in this case be dispensed with.

Messrs. Woodhouse and Rawson.—A catalogue of domestic electrical supplies, or "ironmonger's list," has been issued by this firm, and will be found useful by the large class to whom the applications of electricity are not only of interest, but are possessed of a peculiar fascination. Such persons, wise in their generation and advancing with their times, will, for instance, be pleased with the simple and cheap forms of burglar and fire alarm illustrated on pages 8 and 9, and, being already possessed of a portable electric gas lighter, will scarcely be able to resist investing in a pocket accumulator—an acquisition leading, perhaps, ultimately to the purchase of one of the very beautiful articles of electrical jewellery, *à la Trouvé*, described and illustrated at pages 47 and 48. From an educational point of view, the Student's Dynamo, which can be converted at will from a "series" to a "shunt" machine and *vice versâ*, might be an excellent investment; and the purchase of one of the small electromotors, with a battery to work it, might often constitute the starting-point on the road to a considerable amount of useful knowledge in relation to electrical applications. We notice in the "battery directions" one mistake, perhaps a misprint: to charge the Fuller battery, the tyro is directed to mix pulverised *bicarbonate* (instead of bichromate) of potash with strong sulphuric acid. The result of carrying out this instruction might be so startling, if not serious, that we recommend a retrospective as well as prospective rectification of the error. At all events, no further copies should be issued without the necessary correction.

Australia.—In the Centennial Supplement to the *Sydney Morning Herald*, information is given as to the telegraphic communication in the Colonies. Of New South Wales we read that "postal and telegraphic facilities also exist in every direction. Within the last few years the advantages of the telephone have been added to those of the telegraph, and though telephonic communication as yet only exists between the business houses in town, it is hoped that ere long the towns may be linked together telephonically as they are telegraphically." Of Victoria, the statistics give the number of telegraph stations as 420; miles of line, 4,094; miles of wire, 10,111; telegrams received and despatched, 1,938,049. South Australia is said "in telegraphic enterprise to have had the honour of carrying out, at immense cost, a trans-continental line from Adelaide to Port Darwin, a length of 1,973 miles, thus connecting the Colonies with the telegraphic system of the world. This great work was commenced in August, 1870, with an estimate of £120,000 for expenditure, and completed in the face of the most baffling difficulties just two years later at an actual cost of £370,000. The first message delivered from London by this wire reached Adelaide on June 20, 1872, and the usual time of transit is about six hours. A Telephone Exchange exists in Adelaide, with 1,539 miles of wire. Queensland has 282 telegraph stations, 9,004 miles of line, and 14,443 miles of wire. The returns of Western Australia show 2,885 miles of line. Tasmania has 144 telegraph stations; while New Zealand has 330 stations, with 4,546 miles of line, having 11,178 miles of wire; included in this length are 359 miles of cable, while 79 miles of cable are under construction.

Hydrogen Peroxide.—The question of the electrolytic formation of hydrogen peroxide at the anode has been investigated by M. Traube. From the results of previous experiments it was concluded that hydrogen peroxide is formed by the union of molecular oxygen with hydrogen. Richarz, on the other hand, maintains that hydrogen peroxide is produced by the oxidation of water. When 1 per cent. sulphuric acid is electrolysed in presence of alcohol or hydrogen peroxide at the anode, these are rapidly oxidised. In the electrolysis of a 1 per cent. solution of chrome alum, not a trace of ozone is formed, and chromic acid appears at the anode. When lead is used as anode in the electrolysis of 1 per cent. sulphuric acid, it becomes covered with lead peroxide. These experiments point to the presence of free oxygen-atoms which only unite to passive molecules when there is nothing to oxidise, and also show that water is not oxidised by oxygen-atoms. In the electrolysis of sulphuric acid, it is suggested that persulphuric acid is formed by the action of nascent oxygen, and that this decomposes into sulphuric acid (2 mols.) and hydrogen peroxide (1 mol.) As further proof in favour of the constitution previously ascribed to hydrogen peroxide, it is mentioned that the peroxides of hydrogen, of the alkalis and alkaline earths, of zinc, cadmium, and copper, have quite different chemical properties from those of lead, silver, manganese, and nickel, &c. Only those of the first group yield hydrogen peroxide when treated with acids. The peroxides of the second group can all be prepared by oxidising the oxides or hydroxides in alkaline solution. The peroxides of the first group possess powerful reducing properties, whilst those of the second group are indifferent to oxidising agents. Hence it is concluded that the peroxides of the two groups are differently constituted, and that hydrogen peroxides cannot have the formula HO·OH. The constitution represented by the formula H·O : O·H is considered to be the only one possible.

The Electric Light in Florida.—According to a correspondent of the *Scientific American*, Mr. H. M. Flagler has installed in the Hotel Ponce de Leon, at St. Augustine, the largest isolated (? private) plant for supplying electricity which exists in that country, or, in fact, throughout the world. The installation consists of four Babcock and Wilcox multitubular boilers, each of which has a nominal rating of 107 h.-p.; four Armington and Sims engines, three of 60 h.-p. and one of 125. Each of the 60 h.-p. engines drives an Edison dynamo of the latest type, having a capacity of 64[illegible] sixteen-candle lights. The other engine drives two machines of the No. 16 type. The rating given is nominal, as the plant admits of an increase in power of 25 per cent. over and above the rating. It is doubtful if there exists another electric light plant with so perfect a system of control and regulation. Each dynamo has its own regulator, which controls the amount of electricity produced, and indicators showing the volume and pressure of the electricity. The machines are all connected to heavy bars of flat copper, termed "omnibus wires," with which, by a switch in the headboard of the machines, they may instantly be connected or disconnected. To the "omnibus wires" are connected a series of heavy copper cables, called "feeders," which pass to the most important centres of lighting in the Hotels Ponce de Leon and Alcazar. No lamps are directly connected to these "feeders," but they carry the current to the local distributing points, from which a large number of

ller wires, "mains," lead the electricity to the "ser-ss." These, in turn, conduct it directly to the lamps the buildings. Danger from fire by this system—the son—is reduced practically to *nil*. At the junction nts of the "'bus wires," "feeders," and "mains," are erted fuses, composed of an alloy of lead and tin, ich volatilises at a temperature of 400deg. If by any ident the copper wires conducting the electric current uld come in contact with each other, before the perature of the copper could be raised sufficiently set fire to any inflammable substance in proximity t, the safety fuse would vaporise and open the circuit. soon as the trouble had been rectified, a fresh fusing g would be inserted, and the current re-established in circuit. Nor is there any danger to human life from ning into contact with the wires or machinery of the tem. The pressure is only of about 100 volts, which child can receive with impunity. This plant supplies the lights used in the Hotels Ponce de Leon and Alcazar n all about 5,500 incandescent lamps.

Electrical Lighting of Steamships.—The steam-p "Paula," built for the petroleum trade by Sir W. G. mstrong, Mitchell & Co., at Low Walker, has a complete tallation of electric light, by Mr. Rankin Kennedy, of odside Electric Works, Glasgow. The dynamo is one Mr. Kennedy's single-bobbin machines, capable of sup-ing electricity for 70 sixteen candle-power lamps, and ning at a speed of 750 revolutions per minute. This chine runs entirely without sparking at the brushes, uring a much longer life for the commutator and ushes, which are the principal wearing parts in elec-generating apparatus. The machine is neatly designed, d compactly arranged; every detail of brush arrange-nt and general construction has had careful attention, d it seems to embody in a high degree of perfection the ny improvements which have from time to time been de in the construction of dynamo machinery. The tive power is derived from a Tangyes "Archer" type rtical engine, and is communicated to the dynamo by eans of a canvas and guttapercha belt from the fly-heel to the dynamo pulley. The governing arrangements d regulation of the machine are so complete that the fference in electromotive force in the circuits is less than o per cent., with full load and one lamp respect-ely. Passing from the generating apparatus, a special ature of the installation is the wiring. In the whole ip, with the exception of the saloon and officers' arters, specially protected conductors, consisting of pper wires insulated with vulcanised indiarubber, d sheathed over all with galvanised iron wires, are ed. The joints in these conductors are protected by ecially designed malleable cast-iron joint-boxes, and e whole arrangement makes a very substantial job, lculated to withstand any amount of rough usage thout injury. This is of the greatest importance in troleum-carrying vessels, where the conductors require be specially secure on account of the nature of the de. The fittings in the saloon and the cabins are of at designs, in harmony with other fittings of the ship, d here, as in every other part of the ship, every fitting s its own separate switch, and can be turned on or as desired. The globes in this part of the ip are of pale pearl, and give a particularly pleasing ne to the light. Throughout the whole ship, wherever ht is required, the electric light has been carried, and rangements are also made, and portable lamps with long flexible leads provided, for carrying the light down into the tanks when they require cleaning out or inspecting. The masthead, side, and anchor lamps have also been arranged for electric light. We understand that the same firm are engaged fitting out the "Caucase," another vessel for the same trade (recently launched by the same builders), and that they are putting electric light on two passenger steamers for the Chinese coasting trade, building at Messrs. Hawthorn, Leslie and Co.'s.

Electric Lighting of Trains.—Mr. W. W. Ackworth in the current number of *Murray's Magazine* contributes an article on the Great Northern, North-Eastern, and Manchester, Sheffield, and Lancashire Railways. In this article he describes a great many interesting topics, but, so far as the electric light engineer is concerned, the most interesting will be found in the concluding paragraphs of the article, which refer to the electric lighting of carriages. He describes the system in use by the North British at Glasgow, where, as is well known to our readers, a third wire is laid through the tunnels, and the train is lighted while going through the tunnels. Mr. Ackworth says of lighting by means of accumulators, that they are expensive and heavy, that the cost for charging is great, and the superintendent is hampered by a perpetual feeling of hesitation whether the supply will last till the train has completed its journey. He discusses then the mounting of the dynamo upon the train, and refers to the experiment made by the Lancashire and Yorkshire and Great Eastern with a retort engine—which plan, not being found to answer, was abandoned, though the North-Western has two trains running between Liverpool and Manchester lighted on a somewhat similar system. In this case, if there is a change of engines, unless the new engine carries a dynamo, the light is useless. If, says the author, on the other hand, you can put your dynamo on the train and drive it from the carriage wheels, you are independent of the engine altogether. The Great Northern has five trains so fitted. The author thus describes the Great Northern arrangement for running the dynamo: "We may note, to start with, that unless the passengers are content to sit in darkness every time the train stops, it is impossible to dispense with accumulators altogether. Further, a carriage runs now one end forward and now the other, and the ordinary dynamo must always be driven the one way. This difficulty is in the Great Northern installation got over by an ingenious arrangement of automatic reversing gear. Again, the accumulators are charged from the dynamo. But an accumulator is, so to speak, like a tank of water on a high tower. If the engineer were to connect his pumps with the bottom of the tank, when the power of the engine was insufficient to overcome the downward pressure of the water stored in it, instead of filling the tank, he would only have provided an outlet for its contents. So with the dynamo. Unless it is running about 450 revolutions a minute—in other words, unless the train is going 15 miles an hour (for the dynamo makes five revolutions for each revolution of the carriage axle) it is not producing sufficient electricity to overbalance that already stored up. Accordingly, what is known as a resistance coil is provided, through which the electricity is diverted when the train first starts. As soon as it has reached a sufficient speed an automatic switch cuts out the resistance coil and switches the accumulators into the circuit, to be again cut out automatically as soon as the speed of the train slackens again."

CENTRAL STATION LIGHTING—TRANSFORMERS v. ACCUMULATORS.*

BY R. E. CROMPTON, MEMBER.

The present paper is the outcome of the discussion which took place on Messrs. Kapp's and Mackenzie's papers on transformers, recently read before this society. I was asked to give facts and figures in support of the statement I then made, that I believed the distribution of electricity by transformers offered no special advantages over other methods, particularly over distribution by means of accumulators used as transformers.

However, after compiling the statement of facts and figures necessary for my purpose, I found that I had undertaken a task of a much heavier nature than I originally intended; and I must apologise for the present paper having a much wider scope than its title would warrant.

In fact, I find it necessary to commence by discussing some of the conditions of the supply of electricity from electric stations which are common to all systems of distribution, and about which little or nothing has hitherto been written or said. In England, central station lighting has been such an affair of yesterday, that it is hardly to be wondered that what little knowledge exists on the subject should be confined to the few who have lighting stations under their immediate charge; and when we look to the Continent, or to America, to supplement this meagre stock of knowledge, we find the conditions of demand for light differ from those of a large English town, such as London, so that they do not much help us in our investigation. However, during the past few years I have done my best to make myself acquainted with the main facts which appear likely to govern the future commercial success of such undertakings.

I must at once divide the schemes for electric supply into two classes: 1st, those confessedly carried out in a temporary manner, and for the purpose of popularising the electric light, and inspiring the confidence of the public in supply companies as a form of investment; and, 2ndly, those intended to be of as permanent a nature as the gas supply with which they come into competition. I think to the first class we must relegate such systems of supply as those at Brighton, Eastbourne, the present supply from the Grosvenor Gallery; in fact, all those which distribute by means of overhead wires, picking their customers here and there, and which, although they have served a very useful turn in familiarising the public with the use of the electric light, cannot be considered as in any sense fitted to develop themselves into a complete system of supply when the time arrives that more than half the houses may be expected to take the light.

In order to get an adequate idea of the nature of the demand, or what I call the load diagram of a system of supply, we cannot do better than refer to the diagrams of a similar nature taken by the gas companies. Having recently had the advantage of carrying out electric supply stations for several gas companies, I have had access to such load diagrams for gas lighting, and from these and from the experience already obtained of electric supply in London, I have constructed a load diagram which I believe will be found a fairly representative one for an ordinary London residential district, consisting partly of private houses, partly of shops, with the usual sprinkling of hotels and public buildings. No doubt a district containing a very large number of theatres would have a somewhat different diagram, but not differing so much as to materially affect the arguments that I am about to found on these load diagrams. Through the kindness of Dr. Fleming, I am able to lay before you several load diagrams obtained from lighting stations in America, which, you see, coincide very fairly with the one I have prepared for London. We learn from these load diagrams: 1st, that the average daily outputs in units throughout the year is about three and a half times the maximum load in kilo-watts; in other words, that a station having a plant equal to the supply of 600 kilo-watts—that is to say, 10,000 lamps of 16 candle-power each simultaneously alight—could only calculate on selling an average quantity of 2,100 units per day. This fact, which has such an important bearing on the possible profits to be obtained from a station of a given size, appears to have been completely ignored by the writer of an article on central stations in *Industries*, dated the 2nd December, 1887, who estimates that a plant of this size would be able to supply daily 3,600 Board of Trade units, which is 73 per cent. in excess of the figure I have given above. The next point we have to note, common to all systems of distribution, is the extent of underground mains necessary to distribute a given supply of electricity, and the probable cost of such mains when laid underneath the footways of our streets. Starting once more on the above quoted 10,000-light plant basis, I find, from careful note of the amount of electricity used by various classes of houses, that in order to sell an average of 2,100 units per day our distributing mains must reach not less than 1,000 houses. We may take the average width of the London house at 10 yards; to this we must add 50 per cent., on the supposition that only two houses out of three will take the light for some time to come; and to this we must again add 30 per cent. for such proportions of the roads, such as crossings, dead walls, &c., traversed by the mains which do not front houses taking the light. We thus find that every house requires twenty yards of distributing main; or to distribute the daily average supply of 2,100 units, 20,000 yards of main. In addition to these distributing mains, we must contemplate the probability of the generating station being placed at a distance of 2,000 yards from the centre of the district supplied, so that in all we have to provide 22,000 yards of mains of the two classes of mains. For convenience of nomenclature, I call those mains which form the primary wire to the transformers, or carry the charging current to the accumulators, 'charging mains'; and those from the transformers to the houses, or from the accumulators to the houses, "distributing mains." Next, as to the cost of these mains, I have prepared two tables, which show how wide of the mark is the popular idea that the cost of the mains is greatly influenced by the cost of the copper conductors themselves. I have stated at this institution that much nonsense has been talked on the subject of the cost of copper; by this I did not intend to be disrespectful to any particular speaker, but to point out in strong language that the habit of basing estimates of distribution on the cost of copper (with but a small percentage added for insulation and laying) was one to be avoided, as it has led to erroneous conclusions, on which have been based arguments far too favourable to systems using currents of high E.M.F.

No doubt this habit of considering the cost of copper as such an important element in the calculation has arisen from the fact that, although this question of electrical distribution has been for years under discussion, and has had volumes written about it, yet our experience in laying and repairing such conductors has been until quite recently almost *nil*. The tables now before you are based on the little experience that I have gained during the last three years, and I trust they may be of some service to the members of the institution. Many of the figures are the actual prices paid out on executed contracts, and the other ones are calculated from them; so that it is quite certain that the figures quoted in the table are not far wide of the mark. You will notice that, apart from the price of the copper itself, the additions we have had to make for the insulation troughing, cost of laying, providing and fixing surface boxes, digging and guarding the trenches, taking up and replacing the flagging and wood pavements, are almost a constant quantity depending only on the length of the roadway that is disturbed, and, consequently, when considered in relation to the cost of copper itself, are at a maximum when the section of the copper is small and decrease rapidly as the section augments.

Table I. is for laying copper in the form of insulated cables in the old and well-tried way. Table II. is for a form of main which I have successfully adopted during the past year, and which consists of a bare copper conductor, supported and insulated in concrete subways or culverts by porcelain insulators. I am not at present submitting the latter system for your criticism. In some respects it is not yet perfect; but I mention it as I am employing it to a

*Paper read before the Society of Telegraph-Engineers and Electricians, on Thursday, April 12th, 1888.

TABLE I.—COST OF LAYING 100 YARDS OF DOUBLE CONDUCTOR UNDERNEATH THE FOOTWAY OF A LONDON STREET.

	Single. No. 16.	7/16	19/15	19/12	19/10	37/10	Two Sets. 37/10	Four Sets. 37/10	Six Sets. 37/10
Area, square inch	·0032	·0025	·0773	·1613	0·25	0·5	1·0	2·0	3·0
Area, square millimetre	2·08	14·6	50	104	161·25	322	645	1,290	1,935
Weight per 100 yards run.........lbs.	7½	53½	183¼	392	576	1,153	2,306	4,612	6,918
Cost of copper at 7¾d.	£0 4 10	1 14 6	5 18 0	12 13 0	18 15 0	37 5 0	74 10 0	149 0 0	224 0 0
Cost of insulation	1 3 2	4 8 6	11 2 0	24 17 0	35 17 0	70 15 0	141 10 0	283 0 0	424 0 0
Total cost of cables	1 8 0	6 3 0	17 0 0	37 10 0	54 12 0	108 0 0	216 0 0	432 0 0	648 0 0
Casing, bitumen, and cement	5 3 0	5 5 0	8 0 0	12 10 0	12 10 0	16 0 0	22 0 0	40 0 0	55 0 0
Labour laying	3 0 0	4 0 0	5 0 0	5 0 0	6 0 0	10 0 0	18 0 0	35 0 0	50 0 0
Trenching and repairing	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	30 0 0	35 0 0
Surface boxes and connection	5 0 0	7 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0
Engineer and superintendent	3 0 0	4 0 0	5 0 0	5 0 0	6 0 0	10 0 0	10 0 0	20 0 0	25 0 0
Total	£42 11 0	51 8 0	70 0 0	95 0 0	114 2 0	179 0 0	301 0 0	567 0 0	823 0 0
Add extra, if copper, at 9½d.	0 1 1	0 8 0	1 7 0	2 17 0	3 5 0	8 10 0	17 0 0	34 0 0	51 0 0
	42 12 1	51 16 0	71 7 0	97 17 0	117 7 0	187 10 0	318 0 0	601 0 0	874 0 0
Cost of copper per lb., laid complete	5 13 6	0 19 4	0 7 9	0 5 0	0 4 1	0 3 3½	0 2 8¾	0 2 7¼	0 2 6¼
Current in amperes	1·2	8·1	28	58	90	180	360	720	1,080
Cost per ampere	35 10 0	6 8 0	2 10 6	1 13 9	1 6 0	1 1 0	0 17 6	0 16 8	0 16 1

TABLE II.—COST OF LAYING 100 YARDS OF DOUBLE CONDUCTOR OF BARE COPPER CARRIED ON INSULATORS IN A CULVERT.

Area in square inches	0·25	0·5	1·0	2·0	2·55	3·00
Area in square millimetres	161·25	322·5	645	1290	1645	1935
Weight of copper in lbs. per 100 yards	576	1153	2306	4612	6125	6918
Cost of copper at 7¾d. per lb. £	18 15 0	37 5 0	74 10 0	149 0 0	190 0 0	224 0 0
Laying	9 0 0	9 12 0	9 12 0	9 15 0	9 15 0	10 0 0
Insulators	0 4 6	0 4 6	0 4 6	0 4 6	0 4 6	0 4 6
Six surface boxes and connections	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0
Culvert, 18 inches × 12 inches, for 2 lines conductor, in brickwork and cement, replacing pavement	58 8 0	53 8 0	53 8 0	53 8 0	53 8 0	53 8 0
Engineers and superintendence	6 0 0	10 0 0	10 0 0	10 0 0	10 0 0	15 0 0
Total £	97 7 6	120 9 6	157 14 6	232 7 6	263 7 6	312 12 6
Extra for copper at 9½d. per lb.	3 5 0	8 10 0	17 0 0	34 0 0	43 10 0	51 0 0
Total £	100 12 6	128 19 6	174 14 6	266 7 6	306 7 6	363 12 6
Cost of copper per lb. laid complete	42d.	27d.	18·2d.	13·8d.	12d.	12.6d.
Current in amperes	90	180	360	720	910	1,080
Cost per ampere	1 2 3	0 14 5	0 9 8	0 7 5	0 6 9	0 6 8½

TABLE III.—COST OF 10,000-LIGHT OR 600 KILO-WATT PLANT.

A.T.—ALTERNATING TRANSFORMER DISTRIBUTION.

Generating station, buildings, chimney shaft, water tanks, and general fittings	£11,000
Dynamos and exciters—865 kilo-watts, including spare sets, divided as convenient	5,540
Motive power, *i.e.*, engines, boilers, steam and feed connections, belts, &c., at £8 12s. per I.H.P.	12,470
500 transformers, *i.e.*, one to every pair of houses, at £15 each.	7,500
2,000 yards primary or charging main, exterior to area of supply, at £308 per 100 yards	6,160
20,000 yards distributing main, 50mm. sectional area, at £91 7s. (*see* Table I.)	14,270
Regulating gear	500
	£57,440

B.T.—ACCUMULATOR TRANSFORMER DISTRIBUTION.

Generating station, buildings, chimney stack, water tanks, and general fittings	£8,000
Dynamos—600 kilo-watts, in 6 sets of 100 kilo-watts each ...	4,800
Motive power, *i.e.*, engines, boilers, steam and feed connections, &c., at £8 12s. per I.H.P.	8,600
4 groups of accumulators, in all 240 cells, in series, at £40 per cell, including stands	9,600
2,000 yards charging main, at £306 17s. 6d. per 100 yards (*see* Table II.)	6,137
20,000 yards distributing main, 161·25mm. sectional area, at £100 12s. 6d. (*see* Table II.)	20,125
Regulating gear	2,500
	£59,762

TABLE IV.—WORKING EXPENSES AND MAINTENANCE OF 10,000 LIGHT, OR 600 KILO-WATT PLANT.

———	A.T. £ s. d.	A.T. £ s. d.	B.T. £ s. d.	B.T. £ s. d.
Materials—Coals: 4,380 tons at 17s.	3,723 0 0			
,, 2,550 ,, 17s.	...		2,167 0 0	
Oil, water, and petty stores: 1,500 hours at 7s. 6d. + 7,250 hours at 1s.	925 0 0		...	
,, ,, ,, 1,400 hours at 5s	...		350 0 0	
Total cost of material		4,648 0 0		2,517 0 0
Labour—2 foreman drivers at 45s., 6 drivers at 30s., 9 firemen at 24s., sundry labour.	1,388 8 0		...	
1 foreman driver at 45s., 2 drivers at 30s., 3 firemen at 24s., sundry labour	...		975 0 0	
Salaries—1 chief at £500, 2 assistants at £200 each, 4 clerks at £80 each	1,220 0 0		...	
1 chief at £500, 1 assistant at £200, 4 clerks at £80 each	...	2,608 8 0	1,020 0 0	1,995 0 0
Maintenance of Plant—Motive power and dynamos: 10% on £18,010	1,801 0 0		...	
,, ,, 10% on £13,400	...		1,340 0 0	
Buildings and fittings: 5% on £11,000	550 0 0		...	
,, ,, 5% on £8,000	...		400 0 0	
Transformers: 10% on £7,500	750 0 0		...	
Accumulators: 15% on £9,600	...		1,440 0 0	
Mains: 7½% on £20,430	1,532 5 0		...	
,, 2½% on £26,262	...		656 10 0	
Regulating gear: 10% on £500	50 0 0		...	
,, ,, 10% on £2,500	...		250 0 0	
		4,683 5 0		4,086 10 0
		11,939 13 0		8,598 10 0
2,100 units × 365 days = 766,500 units. Cost per unit	...	3·75d.	...	2·7d.

considerable extent myself, and believe that it will prove a very valuable form of conductor for whatever system of distribution is used. The completed main consists of such very durable materials, and the facilities for repairs and renewals, or for increase in the section of the conductor are so great, that the annual charge for the upkeep and depreciation of these mains is not likely to exceed 25 per cent. of that of the older form of cables insulated with the continuous covering, whatever material may be employed for that covering.

With these considerations of the load diagrams, the extent of distributing system, and the cost of the mains before us, we can now proceed to compare the merits of distributing the electricity by two systems—the first being by alternating currents of high E.M.F., transformed to currents of low E.M.F., suitable to the glow and arc lamps used by the consumers, and which I hereafter call the A.T. system; and second, the supply by means of direct currents of medium E.M.F. used to charge accumulators arranged in series, the current being taken off the accumulators at the lower E.M.F. required for the lamps, and which I hereafter call the B.T. system.

All modern systems of distribution aim at the reduction of the first cost of the distributing plant—that is, of the charging and distributing mains, and all appliances belonging to them, such as transformers, regulating devices, street surface boxes, house connections, &c., providing that such reductions shall not be at the expense of the efficiency of the system. It is difficult to fix an exact percentage of the loss allowable in the distributing plant, as so much depends on the length of the working hours; but I take it for granted that in no case must this loss exceed 10 per cent. I further take it for granted that the extreme variation allowable in the E.M.F. in the distributing mains must not exceed 4 per cent. So much has recently been written on the A.T. system that I will not lengthen this paper by describing it further than by stating that for purposes of my comparison I take the system as generally described by Mr. Kapp in his paper on transformers; or by Mr. Mackenzie in his paper on transformers; and in an article in *Industries*, dated December 2nd, 1887, for which I believe Mr. Kapp is responsible, and which gives very complete data on the first cost of an installation for 10,000 60-watt lamps, burnt simultaneously. On the other hand, it is necessary for me here to briefly explain the B.T. system, which I propose to compare with it.

At Vienna, the arrangements proposed by Mr. Monnier, and successfully carried out by myself and others, consist of charging from a central station groups of batteries of accumulators arranged in series. Each group of accumulators consists of 52 cells, giving the 100 volts required for the lamps, with a comfortable margin. The total E.M.F. required to charge the four groups of batteries in series varies from 430 volts, at the time the batteries are giving off work, to 480 volts, for the short time during which the charge is being completed. This includes the loss in the mains, generating stations being situated 1,400 yards from the distributing station. During five hours of lighting about two-thirds of the current comes direct from the dynamos; but during this time for short periods the demand of current often increases to such an extent that these proportions may be reversed, and the batteries supply two-thirds of the total. As this system has now been in use for upwards of nine months without any hitch or trouble whatever in connection with the electrical work, we may consider it proved there is no danger or difficulty in using currents of such high E.M.F. as 480 volts connected permanently to the distributing mains. The system may, of course, be united with three or two groups only in series. An example of the last is the central station belonging to the Lemans Gas Company.

I now propose to commence my comparison of the two systems from four points of view:—1st, as to trustworthiness, steadiness, and quality of the lighting; 2nd, as to first cost of the plant; and 3rd, as to working cost and maintenance; 4th, as to the probable output, and hence maximum income, that can be safely obtained from the sale of electricity in each case.

I think it will be allowed that the commercial success of an electric light undertaking depends on these four points. I do not propose to dwell much on the first point. It is generally admitted that a system which uses storage must be superior to a system in which the continuity of the lighting depends entirely in moving machinery. There are many reasons why I should not make invidious comparisons on these points between existing systems. No one is prepared to dispute the facts that the A.T. systems hitherto installed have been remarkable for frequent interruptions in the lighting, whereas the reverse has been the case with the B.T. system. It remains for us to consider whether the undoubted great advantages which the B.T. system possesses in this respect is not purchased too dearly; and this matter will occupy the remainder of my paper. The comparison I now make is for a system of electrical supply for London for 10,000 60-watt lamps, or their equivalent, simultaneously alight at hours of maximum demand:—1st, by alternating currents reduced from 2,000 volts to 60 volts by transformers; 2nd, by direct currents reduced from 440 volts to 110 volts by accumulators used as transformers.

Cost of Generating Station.—For the A.T. system I adopt the figures given by the writer in *Industries*, on page 600, of the 2nd December, 1887. He therein proposes to provide for the 10,000 lamp plant dynamo power, including reserve equal to 865 kilo-watts, and he fixes the price of those as £5,540. As regards motive power, I do not propose to take advantage of the writer's far too liberal estimate of its cost at £12 per I.H.P., but take it at the lower figure of £8 12s. per I.H.P., thus reducing the cost to £12,500. I have estimated the cost of the building, chimney stack, water tanks, connections for water, drains, all measuring instruments, and other accessories, at £11,000, thus bringing the total cost of the generating station of the A.T. system to £29,040. For the B.T. system I propose to provide plant of exactly similar type to that I have already supplied to Vienna. As I have said before, I propose that the dynamos should supply two-thirds of the maximum net output of 600 kilo-watts. We therefore require about 448 kilo-watts at the terminals of the accumulators; or, adding an 8¼ per cent. loss in the charging mains, 490 kilo-watts in the generating station; 20 per cent. of reserve power will bring this up to 600 kilo-watts equal to 1,000 I.H.P. Such a plant may be conveniently divided into six sets of combined engines and dynamos each of 100 kilo-watts. Adopting the figure given above—viz., £8 12s. per I.H.P., at the cost of the motive power and that given by the writer in *Industries* at £8 per kilo-watt, or £4,800 for the six sets of dynamos, and estimating that the cost of the building and other accessories as before detailed, for the A.T. system will, in this case, be only £8,000—we find that £21,500 is the cost of the generating station for the B.T. system.

The cost of the alternating transformers is a very difficult matter to arrive at. The Grosvenor Gallery Company, I believe, with few exceptions, supplies every consumer with his own transformer; but Mr. Kapp, in his recent paper proposes to lay down a network of mains of much the same character as I use for the B.T. system, and to supply this network by a certain number of larger transformers, placed at frequent intervals in the network. It is difficult to see how any saving can be made by this arrangement. It will be noticed that, although it reduces the number of transformers, it introduces a new element of expense and difficulty, and that is, the providing of places to fix these large transformers. It may be that such places can easily be found, but my experience has been otherwise. It is not easy to find a place for any piece of machinery of a size between that which can conveniently be got into a surface-box placed in the pavement not exceeding 1ft. in depth by 2ft. square, and a sub-station of the size I require for my battery transformers. In most cases there is no space either under the footways or under the street itself to form a water-tight chamber of sufficient cubic capacity for the purpose. Another difficulty and cause of additional expense, which I think would tend to counterbalance any saving from the decreased number of transformers, would be that the charging mains laid *to* the transformers, and the distributing mains *away* from the transformers, would have to be laid in the same trench or culvert, and this would be no small source of danger to those at work connecting houses on to the distri-

buting mains. As I have not been able to obtain any reliable data on this modified system of Mr. Kapps, I am obliged for the present to return to the system using one transformer for every two houses, and I think, for the reasons I have given above, the advocates of the A.T. system will not be able to make any great saving by adopting Mr. Kapp's suggestion.

Accumulators, to be used as transformers, must be of sufficient capacity to supply 200 kilo-watts per hour for the hours during which the demand exceeds the 400 kilo-watts supplied by the dynamos. The load curves, shown on the diagram hanging before you, show that this period of maximum supply varies from about two hours in summer to four in winter. If I provide four groups of accumulators, each of which has a total capacity of 259 kilo-watts, or 1,000 kilo-watts for the four, I provide for five hours of extreme demand, which is a condition of things extremely unlikely to occur, even in times of a fog. For it must be noted that the demand for light during a fog in the daytime (in a district partly residential and partly supplying shops) is of a far lighter nature than the demand from the same district during the ordinary hours of maximum lighting; the reason being that, during the hours of maximum lighting, not only the lamps in the basement passages and a certain portion of the dwelling rooms require to be simultaneously alight, but all upstair passages and a certain proportion of the bedrooms also require light. This is not the case during a fog; only the basement, lower passages, and living rooms take the light, and these to not nearly the same extent as they do in the evening. In order to meet a case of possible interruptions to the charging current which might take place at the time of maximum demand, we require these accumulators to be capable of being discharged without damage to themselves, and at a fair rate of efficiency, at a rate not less than 650 kilo-watts. It is this latter requirement that has so long delayed the introduction of accumulators as transformers. Up to a recent date far too much attention has been paid to the capacity, and too little to the rate of possible maximum discharge. This state of things has lately been remedied, and I am told there are several makers of accumulators who can supply them to fulfil the above-mentioned conditions, and at the reasonable price named by me in my estimate. It must be remembered that such accidental stoppages of the lighting current as are likely to take place would not probably last for more than a few minutes—that is to say, if due provision has been made for spare machinery, and if the arrangements for working the machines parallel and interchangeable have been properly carried out. Time will not permit me in the course of this paper to describe fully the switch board and regulating arrangements necessary for the B.T. system. These require to be so arranged that the loss due to the difference of E.M.F. between the charge and discharge of the batteries may be as small as possible. It is quite possible to work the batteries parallel to the charging current during the hours of maximum demand with little or no loss from this cause, the loss being confined to the hours when the batteries are being finally filled up before the engines are stopped. The sub-stations, which contain the accumulator transformers, can in almost every case be placed on "mews" property; and I have ascertained from accurate inquiry that there is no difficulty in obtaining accommodation for them in such property, with but few exceptions, within 300 yards radius of the houses to be supplied. In each case the sub-station consists of a battery-room and living-room for the man in charge. The plant in each sub-station consists of the batteries themselves, the regulating appliances above mentioned, voltmeters, and district meters as may be thought necessary.

Distribution.—In the case of the A.T. system the charging mains, as far as they lie within the area of supply, are in reality the distributing mains; in other words, we require 20,000 yards of distributing mains to reach the houses. I am informed that the section usually employed for the distributing mains of these 2,000-volt circuits, when the transformers are placed in parallel, is 50 millimetres cross section, or 19 strand, No. 15 B.W.G. From Table No. I you will see that this costs £71 7s. per 100 yards. I have not worked out the cost of so small a section laid on my own plan in the culverts, but it would certainly not be less than £96 per 100 yards. However, adopting the lower figure, the distributing main will cost £14,270. The writer in *Industries* says that 720 kilo-watts will have to be generated at the generating station for transmission to the area of supply; dividing this by 2,000 volts, we get 360 amperes as the current in the charging main. Adopting Professor Forbes' tables for calculating the section of the conductor, we find that it ought to be about 645 millimetres, and if laid in the cable form, as in Table I., but without surface boxes, would cost about £308 per 100 yards, or in all £6,160. It will be asked why I do not give to these charging mains the advantage of the somewhat lower cost of laying them as bare copper, as in Table II.; but I do not think it would be safe to leave conductors carrying currents at 2,000 volts thus unprotected in the culverts, as the risk to workmen employed on the district system would be too great, to which must be added the great risk to the consumers of making an accidental contact from the charging to the distributing mains. I should here remark that the very confident tone adopted by many supporters of the A.T. system rests on very slender foundations; they appear to forget that the great success obtained in America has been with overhead wires used as the primary or charging mains. We all know what a high degree of insulation is possible with overhead wires; we also know that extreme difficulty has been met with in America in all attempts to obtain sufficient insulation for wires carrying currents of high E.M.F. when laid undergound. As a matter of fact, failure has been the rule, and success the exception. I believe that the difficulties of the A.T. system will commence when the contractors have to guarantee a perfect insulation with undergound cables carrying currents at an E.M.F. of 2,000 volts. Let those who think otherwise read Prof. Elihu Thomson's remarks at the recent electric light convention in America. He used the following words: "Distribution of current to groups of incandescent lamps, arc light, or other high potential lines should always be undertaken with great care; and it is thought that such work should only be undertaken when exceptionally favourable conditions for avoiding accidental leakages exist, especially should the potential of the line at the dynamo exceed 1,500 volts, or an amount which would sustain 30 arc lamps in series. One of the important elements of safety in such installations is simplicity and ease of inspection of the wiring, and no concealed wires should be used in them." Again he says: "For house to house and general incandescent lighting, where the distances from the station are not too great, the direct low potential systems possess most of the advantages, the difficulties of leakage from the defective insulation being of course at a minimum; but where the distances are so great as to make the required outlay for copper in the conductors practically prohibit the extension of the system, a transformer or converter system, if of good design and economy, may be made to yield excellent results." Now, the writer of these words is one of the greatest authorities on electric lighting matters in America, and a strong supporter of the A.T. system. I think, therefore, that I have not dwelt too strongly on the grave difficulties likely to be encountered by those who so glibly talk of laying underground charging mains, carrying currents at 2,000 volts potential, and I think that in all probability the additional precautions that will have to be taken to avoid failure of the insulation will be so expensive as to bring the total cost of the 22,000 yards up to practically the same sum as is required for the 2,000 yards of charging main and 20,000 yards of distributing mains of the B.T. system, for which no such special precautions are necessary.

I work out the cost of the latter as follows:—I use throughout bare copper mains of ·25in. section for the distributing mains—that is to say, for the 20,000 yards, at the rate given in Table II. of £100. 12s. 6d. per 100 yards, they will cost £20,125. The charging main will have to carry 910 amperes, and the extreme loss allowable being 8·25 per cent., its resistance must be 0·04 ohms. The double conductor will weigh about 45 tons; this can be laid, as in Table II., in brickwork, in cement culvert, at the rate of £306. 17s. 6d. per 100 yards, or £6,137. 10s.

I have put down an item of £500 for the regulating gear for the A.T. system, and another one of £2,500 for the regulating gear for the B.T. system. The totals thus arrived at, and which you see before you on the wall, are £57,440 as the total cost of the A.T. system, and £59,762 for the B.T. system. These figures appear high; but I cannot see how they can be reduced, unless under very exceptional circumstances. In both cases a very large portion of the cost lies in the distributing plant; and of this, as you will gather from my Tables I. and II., the copper plays but an insignificant part, the real heavy charges being those inseparably connected with underground cables—viz., the cost of insulation and those connected with disturbing and replacing the surface of the streets.

Comparison of working and cost of maintenance; coal bill of the A.T. system.—The generating plant on the A.T. system has to run continuously—that is to say, that the larger engines will be run for an average of three hours per day; and if it be found practically possible to subdivide the plant into a number of engines, and work them parallel, as is the case with the direct current system, we may be able to credit the engines and dynamos with an efficiency of 75 per cent during these hours. In order to meet the average demand of 2,100 units per day, the load diagrams show that they will vary during these hours from 400 to 720 kilo-watts. We have as yet been furnished with no actual data as to the actual efficiency of the alternating transformer system at various rates of output, that is, the E.-H.-P. actually delivered to the lamps, divided by the E.-H. P. at the terminals of the dynamos. It must be recollected that as the transformers must be large enough to supply the maximum demand of each house, whereas the maximum demand that the station can supply is probably not more than one-third of this, the transformers during this period of three hours cannot be more than one-third loaded, and therefore it is not probable that their efficiency is more than 70 per cent. It follows that, during the hours when the plant is working at 500, 400, and 300 kilo-watts, the total efficiency—that is, E.-H.-P. delivered at the lamps, divided by the I.-H.-P. in the engine cylinders, including loss in mains—will not be above 54 per cent. Supposing that the steam engines can work at 2½ lb. of coal per I.-H.-P., the net quantity required per E.-H.-P. will be 4·65lb., or 6·2lb. per kilo-watt. The output during these hours may be considered as 60 per cent. of that of the whole day, or, say, 1,260 kilo-watts; therefore about 70cwt. will be used during these three hours. During the remainder of the 21 hours the transformers will be working at a very small rate of output. It is probable that their efficiency will be reduced to 30 per cent., and the efficiency of the steam engines and dynamos to 50 per cent., or a total efficiency—that is, E.-H.-P. at the lamps, divided by the I.-H.-P. of the engines—of 15 per cent. only; therefore, during this period it seems probable that 17lb. of coal will be used per E.-H.-P. or 22·5 per kilo-watt. Therefore, the coal used in producing the balance of the daily output of 840 kilo-watts will be about 8 tons 8 cwt., or, making a small allowance for the lighting up of boilers, 12 tons per day. The oil, water, and petty stores may be calculated at 7s. 6d. per hour for three hours during the day, and at 1s. per hour during the remainder of the time. Therefore, the total cost of material used in running this station will be £4,849. The B.T. system, on the other hand, will show great saving on this. For the output of 2,100 units it will be sufficient to work the generating plant for about five hours at approximately its greatest rate of efficiency. I have had ample experience with this class of plant, and know that we can in actual practice produce the E.-H.-P. at the terminals of the dynamo with the expenditure of 3½lb. of coal. Taking the maximum loss in the accumulators, the efficiency of the system—that is, the E.-H.-P. at the lamps, divided by E.-H.-P. at the terminals of the dynamo—will be not less than 80 per cent.; therefore, we may say that each unit at the lamps can be produced for 5·75lb. of coal, or 5 tons 8 cwt. per day, or allowing a 25 per cent. margin for contingencies, 2,550 tons per annum. The water and petty stores may in this case be taken at 5s. an hour for 1,400 hours; the total cost of the material for producing 2,100 units by the B.T. system will be £2,517, or only about 57 per cent. of the cost of material by the A.T. system. *Turning now to the labour in the engine room*, the table before you shows that, as in the case of the A.T. system, the hours are continuous; three shifts of men will be required: it is necessary to have two foremen, six engine drivers, and nine firemen, whereas in the B.T. system there is only one shift of men: one foreman, four drivers, and three firemen are employed. I have only estimated for two extra men in the engine room for the A.T. system, but for the B.T system I have allowed for four accumulator foremen in charge of the four accumulator stations, and two messengers. The totals thus arrived at for labour for working the systems are £1,389 8s. 8d. for the A.T. system and £975 for the B.T. system. The salaries are £1,200 for the A.T., and £1,020 for the B.T. system. The last item we come to is one for *repair and renewals*. In both cases I have allowed at the rate of 10 per cent. on the motive power of engines and dynamos, 5 per cent. on the buildings and fittings, 10 per cent. on transformers, 15 per cent. on accumulators, 7½ per cent. on the insulated mains that have to carry 2,000 volts, 2½ per cent. only on the bare copper mains (the majority of which only have to carry 110 volts) 10 per cent. on all regulating appliances. Thus, nearly the heaviest item, the *maintenance*, comes to £4,683 5s. in the A.T. system, and £4,086 10s. for the B.T. system. The gross cost of producing 776,500 units by the A.T. system would be £11,939. 13s., and the B.T. system would be £8,598. 10s., or 3·75 and 2·7 per unit respectively. In order to make a fair comparison between the two plants when worked in the most economical manner, if the generating station of the B.T. system is worked longer hours, it can actually produce the daily average of 3,600 units named by the writer in *Industries*; in order to do this the sole increase in the working expenses would be in the materials, to which £1,800 would have to be added. The cost, then, of 1,314,000 units would be £10,398. 10s., or 1·9 per unit by the B.T. system.

It will be seen, therefore, that while by both systems there is a probability of a fair return on the capital expenditure, yet in almost every respect the B.T. system is a more economical one. This arises from the fact that the main cause of expense in the A.T. system, depending, as it does, on continually moving machinery, is the heavy cost of material, labour, and superintendence during the long hours in which the machinery is working very lightly loaded. The B.T. system shows very favourably in this respect, as even at the latter increased output of 3,600 units per day the machinery need not work, on the average, more than ten hours, so that one shift of men can do the work, and there is ample time for repair and inspection of the machinery.

LITERATURE.

Management of Accumulators and Private Electric Light Installations: A Practical Handbook. By Sir DAVID SALOMONS, Bart. Third edition, revised and enlarged. Whittaker and Co. 1888.

We understand that so great has been the demand for this book, that a fourth edition is in preparation. For readable, trustworthy, practical books there is plenty of room, while it would be better, both for pure and applied science, if a fair proportion of the so-called school and text books were burnt by the common hangman. Sir David Salomons has provided a work of the former kind—in fact, the only work of its kind—and the information given is all the more valuable in that it is almost entirely the outcome of practical observation. It is not the first time in the annals of applied science that wealthy amateurs have done what those professionally engaged have either been unable or unwilling to do. From the first introduction of electric lighting Sir David Salomons has been experimenting to obtain a complete and satisfactory installation at his residence, Broomhill. Hence he is able to say, "The contents of this little book is the result of years of labour regardless of expense, so as to ensure results of a satisfactory nature, which are only possible by conducting endless experiments."

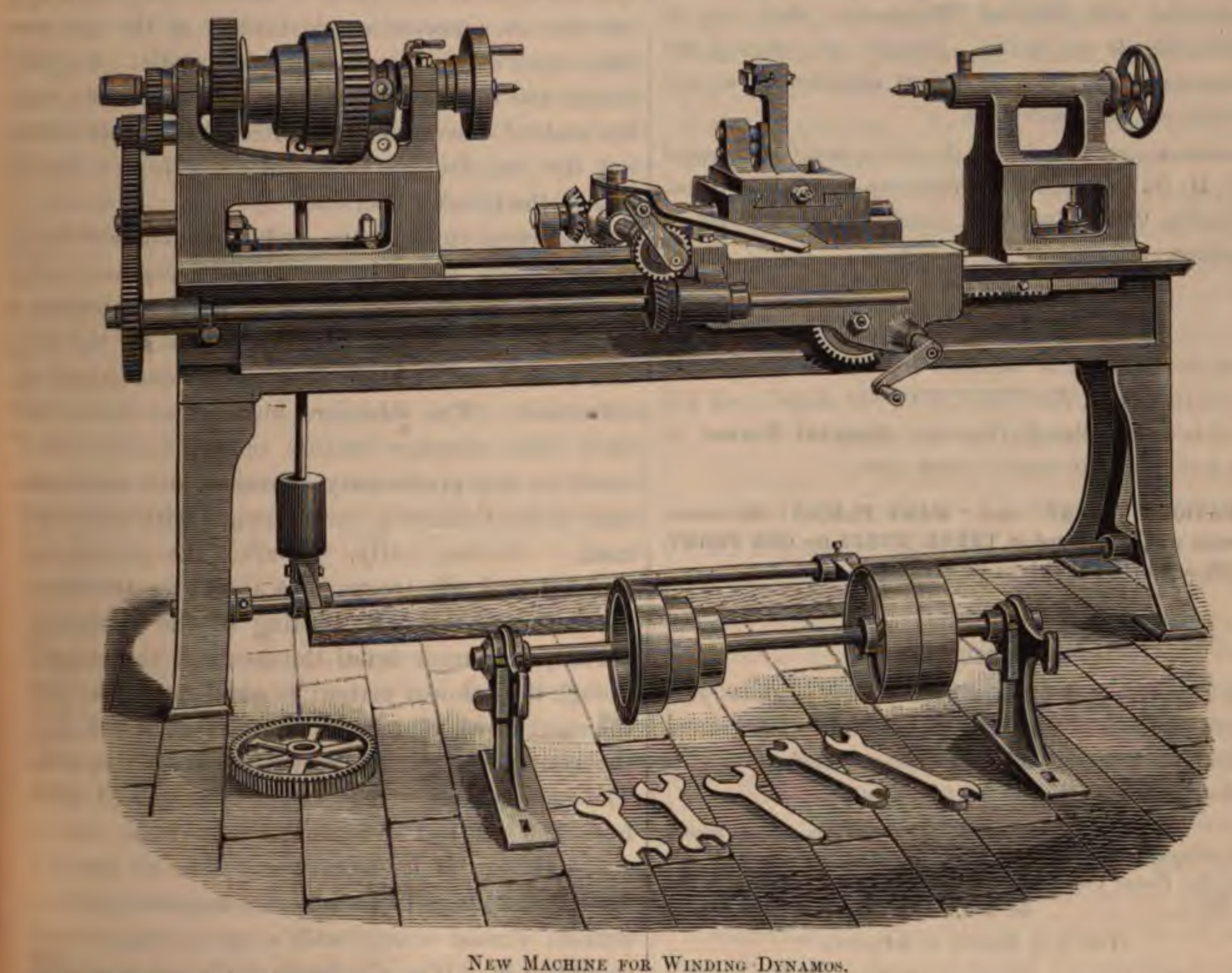
The great value of such a book as this is that it does not pretend to be written from the sublime heights of science. We do not read between the lines the assertion that "I am the only true prophet." Far better would it be if more books had as many grammatical errors and as much common-sense information. The man who has to look after accumulators wants to know in the simplest manner what to expect, and if anything goes wrong how to put it right, and this is just what Sir David Salomon tells him. It may be well to let the author speak for himself, or, as Old Humphrey would have said, "let us sample him." Here are a few "dont's," p. 62. "Never add concentrated acid to the cells, the grids will soon become rotten if this is done. Never test if E.M.F. exists in the cell by "flashing," which means taking a short wire, placing one end firmly on the positive strip of a cell and rapidly touching the negative strip, giving in this way a flash if the cell is right. It is the old method of testing, which soon spoils the cells if frequently done, and no scientific result is obtained. The proper way to test is with a voltmeter as before described."

There are many things that might be criticised in the book, but we think the practical statements far outvalue what we should object to. Still, it would be sufficient to say that the best grease for lubrication, according to the author's experience, was that supplied by Elwell Parker, without particularising that 5s.-worth would go as far £5 of oil, and, in fact, to speak in many places more generally, because no individual now can have sufficient experience to warrant him placarding the best of everything.

One of the most interesting chapters in the book is the last, wherein the author details the history, development, and cost of the installation at Broomhill.

MACHINE FOR WINDING DYNAMOS.

The machine or lathe herewith illustrated has been designed by the makers for a definite object—the winding of dynamos. The development of any new industry, and especially an industry that is more or less a branch of mechanical engineering, leads sooner or later to the construction of special machines to decrease the cost of manufacture. This is the case as regards the construction of dynamos. In their early days the winding of the armatures was a source of continued trouble, and was a very expensive operation, nor was such winding ever perfectly satisfactory. Machinery will introduce greater regularity. Of course, all armatures cannot be wound by a machine, but those of Kapp, Mather-Platt, Crompton, and similar machines can be so wound. The drum upon which it is desired to wind the wire is placed between the centres of the machine, as in a lathe, and driven at the proper speed for winding. There is an instantaneous stop motion by treadle, by which the attendant can stop the machine when required. On the bed is a travelling carriage with an adjustable tension wire feed, the wire being fed from the coil behind the machine. The feed is geared up for the necessary thickness of wire, and the wire is wound on evenly and at the proper regular tension, the feed being reversed by hand until the proper amount is wound on. It is calculated that with the aid of this machine one man can do more and better work than two men working in the ordinary way. The machine we illustrate is made by Messrs. Wilkinson and Lister.



New Machine for Winding Dynamos.

Results of Tenders.—A gradually increasing number of local authorities are using electrical apparatus in some shape or other. Many are connecting the members of the fire brigade telephonically, or by means of bells, and no doubt a large business may be done in this direction when electricians become alive to the fact that the field awaits their advent. Aldershot has recently invited tenders for connecting the members of the fire brigade by means of electric bells. The following are the firms that tendered, and the respective amounts of each tender:—Mr. Tily, Farnham, £38 18s. 9d.; Messrs. Dale, London, £78; Messrs. Franklin, Reading, £15 10s. 6d.; and Messrs. Steven and Johnson, Aldershot, £45.

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. Graves, Esq., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. Wollaston, M.D., F.R.S. *Next week we shall give that of* Sir Humphrey Davy, F.R.S., *whose fame as an electrician is still more prominent than that of* Wollaston. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* Prof. D. E. Hughes, F.R.S.

THE BATTLE OF THE GIANTS.

Transformers or accumulators, that is the question; and whether it is better in all respects to use the one or the other has not yet been decided. The siege of Troy was a lengthy combat—filled with some stirring episodes; but there sword and spear formed the conquering weapons, and the deeds of the heroes have been sung to every successive generation. The contest between transformers and accumulators is of another kind. The arena may witness a victory as far-reaching as that of the Greeks over the Trojans, and of greater benefit to the world at large; but there will be no Homer to sing pæans to the victors. The struggle is not likely to be over for years, nor can the ever-increasing skirmishes of the present have much effect upon the ultimate results. Pocket-pistols and huge and massive manuscripts may turn the scale of debate in the theatre of the Institution, but the real decisive blow will come from a future giant—the Giant Experience

The transformer troops, under the able leadership of Mr. Kapp, entered recently into the war, with banners flying and trumpets sounding, to encounter a steady and determined resistance all along the line, and it can hardly be said that ground was gained on either side. The defenders, however, of that attack have taken courage because of the unsatisfactory result of this preliminary skirmish, and, under the ægis of Mr. Crompton, have charged with might and main. Writing early, yet after the reveille has sounded and the troops have armed for the battle, but before the actual meeting of the contending parties, we cannot detail the result of the struggle, though it is almost certain we shall not be far from the mark if we venture to foretell that it will leave the contending parties pretty much as they were. The experience that has as yet been gained, either from the use of transformers or from that of accumulators, is far from being able to lead to a decisive opinion. The staunchest supporter of transformers almost always adds a saving clause to his argument in, "If accumulators can be obtained which may be depended upon for economy and lasting properties, then they will provide a better means of distribution than by transformers," but he adds in an aside: whatever may be said to the contrary "such accumulators are not in existence yet." The supporter of the accumulator agrees with his opponent *sotto voçe*, yet aloud disputes that his apparatus is imperfect. No one has yet formulated the requirements for a perfect accumulator, nor are we going to venture where the giants fear to tread. When one or the other of the leaders will define what is wanted or what can be given, as clearly as we can define what the industry would like to obtain in incandescent lamps—for example, thus: "a lamp with three watts per candle to give twenty candles for a thousand hours, without blackening to the

extent of losing one per cent. of the light, and costing eighteenpence"—then we can say how far the perfect accumulator will permit them to do what is required in central station lighting.

We Englishmen are apt to magnify the meaning of our words. A river here would be a brook, if not a ditch without a distinctive name, in America. Anything above a couple of score of lights is a central station here. It makes us feel large and think much of ourselves to be able to talk about so many central stations; but, after all, when we really come to look into the matter, what does it amount to? The Grosvenor Gallery installation may be approaching its 20,000 lamps, and that is the only one at present worthy of the name "central station" in the whole country. The experience of the Grosvenor Gallery has been wholly in the direction of transformers, and if we may credit unsolicited, and, so far as we can judge, unbiassed testimony, the result is not quite perfection. The experience at Kensington Court is not sufficiently large, nor is the experience at Vienna sufficiently lengthy, to warrant a decisive conclusion from the results obtained. There is a tale about a man whose mule was a little restive under chastisement, and indolent without. A castigation was necessary, and a stick was pulled from the adjacent hedge. It broke at the first stroke; another, stouter, greener, and tougher, was obtained, and for thirteen consecutive whacks appeared uninjured, yet on the fourteenth it also broke to pieces, and the mule was still indolent. Æsop always wrote a moral to his fables for fear the Greeks should not see it; and, following so admirable an example, we say accumulators may look well for one or two months or years, but may go to pieces the third month or year. Has experience shown that you may rely upon a depreciation of 10 per cent. being within the mark? What is the depreciation to be allowed that will give satisfaction all round?

If we have said too much about accumulators, and too little about transformers, as it is necessary to bestow an equal share of favours, attention may be directed once more to the great and almost constant loss that arises from working machinery far below its normal output. This result must, we fear, happen when transformers are used. A house wired for fifty or a hundred lamps will, as a rule, not turn on more than a fifth of the number, yet its transformer must be designed to supply current to the maximum number. What about efficiency under these circumstances? Extended experience alone will give us the facts and figures required, while the facts derived from a limited experience may become of the nature of fictions under the clearer light of time. In the workshop and the laboratory, our tests are made under the most favourable conditions, and of course efficiencies are satisfactory. The present transformer and the present accumulator are progressive steps in the evolution of the electric lighting industry, and will play their part just as the Alliance machine played its part, and will give place to something more perfect and more efficient. Still, what we have will enable us to do what could not be so satisfactorily done three years ago; and taking into consideration the circumstances of each special case, the engineer will determine which is the better for that particular installation—transformer or accumulator. This discussion is one that more particularly interests the industry, and not the public. We know that an installation can be carried out with either; and the public will not be deterred from purchasing because one firm advocates transformers and another accumulators, any more than they are deterred from purchasing steam engines because one maker advocates stationary and another semi-portable engines. Nor has efficiency much to do with the public, when all the contention is about ·001 or ·002 per cent. of the original energy when normal conditions operate. Go on, then, thrashing out these points of detail, tabulating experience, fighting for opinions as held now, but leave a loophole for change due to the further experience that is to come.

ELECTRICAL TRAMWAYS.

The paper of Dr. E. Hopkinson on the Bessbrook and Newry Tramway, read before the Institution of Civil Engineers, with the discussion thereon, forms the completest survey of electrical traction as applied to tramways that exists. The importance of the subject is so great, that, feeling that all information upon it should be disseminated as widely as possible, we have obtained permission to reprint from the Institution's proceedings this paper and the discussion, for the benefit of those of our readers who may not be members of the Institution or see the Proceedings. It will be seen that "the conductor is of channel steel, laid midway between the rails." In considering the applicability of electricity for haulage purposes, we have to consider the special conditions holding in each case. In America, many conductors are overhead. At Blackpool, Mr. Holroyd Smith uses the central channel—a system which in a modified form is adopted at Bessbrook. In many cases neither of these systems is permissible, and only if accumulators can be economically applied will electricity be used. Overhead wires cannot be allowed in large towns, and local authorities absolutely refuse permission to lay a central channel, so that the field of operations is considerably narrowed. As we say, a vast amount of information relating to all these systems will be found in the paper and discussion. In many places in America, and in sparsely populated districts, or for feeding lines to main lines of railway, overhead contact is permissible.

PATERSON AND COOPER'S FITTINGS.

We illustrate this week some new fittings designed by Messrs. Paterson and Cooper for installation work. Figs. 1 and 2 represent, to a scale of half size, neat forms of switches for single lamps or for groups of from two to eight lamps. Fig. 1 is mounted on a slate or serpentine base, with polished brass or bronze dome, the knob for turning

FIG. 1.

FIG. 2.

off and on being of ebonite. Fig. 2 is mounted on a porcelain base, and has a grooved brass cover secured to the base by a bayonet joint. Both forms have throw-off springs concealed inside the switch. Larger sizes are made in similar patterns to carry current for 16 lamps.

FIG. 3.

Fig. 3 represents double-pole main switches made in sizes to carry from 25 to 500 amperes. The pole blocks are mounted on a slate base, having a teak fillet round it, the throw-off springs being concealed under the base. The contact blocks, of which there are two, are carried by the brass cross-piece, and kept up to the pole blocks by a strong helical spring, as shown.

FIG 4

Fig. 4 shows a magnetic cut-out designed for use with accumulators, the action of which is simplicity itself. It is placed in the charging circuit, and its working depends on an electro-magnet excited by the charging current. This is mounted on a slate back, its armature being attached to one end of a bell-crank lever. To the other end of the lever is fastened a bridge piece, the two ends of which dip into mercury cups formed in a boxwood block. The connections are from the right-hand terminal to the right-hand cup, from the left-hand cup to right-hand end of magnet coil, and from the left-hand end of magnet coil to left-hand terminal. The circuit is therefore completed through the bridge piece, the ends of which dip into the mercury cups. When the charging current gets too low, the armature, from the weakening of the electro-magnet, falls, lifting the bridge piece and thus preventing a reversal of the current. By a milled nut the cut-out can be adjusted to break the circuit at any particular current within fairly wide limits.

AN ELECTRIC FIRE ALARM.

The accompanying illustrations show a new device for the indication of fire by means of an electric alarm. An examination of the figures will show that the contact is made by the expansion of a membrane. Fig. 1 shows

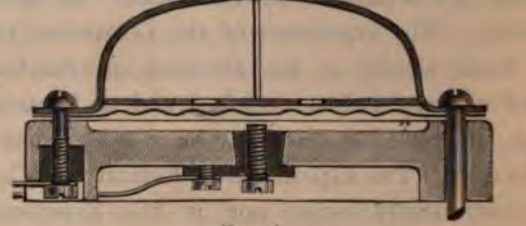


FIG. 1.

the membrane not in contact with the central screw. Fig. 2 shows that under the increased temperature expansion has taken place, and contact has been made with the said screw. This completes an electric circuit, and an alarm is set in motion at any point it may be found desirable. The arrangement is certainly ingenious, and it seems that the only difficulty is that there may be a sufficient rise of temperature from ordinary causes to set the alarm going without any danger of fire; but this, perhaps, might be an advantage, as many would suggest, prevention is better

FIG. 2.

than cure. On the other hand, unless the alarm was suitably placed, it might happen that the fire would get well hold without raising the temperature near the alarm sufficiently high to bring it into action.

E. RAUB'S NEW THERMO BATTERY.*

BY G. BETZ, BERLIN.

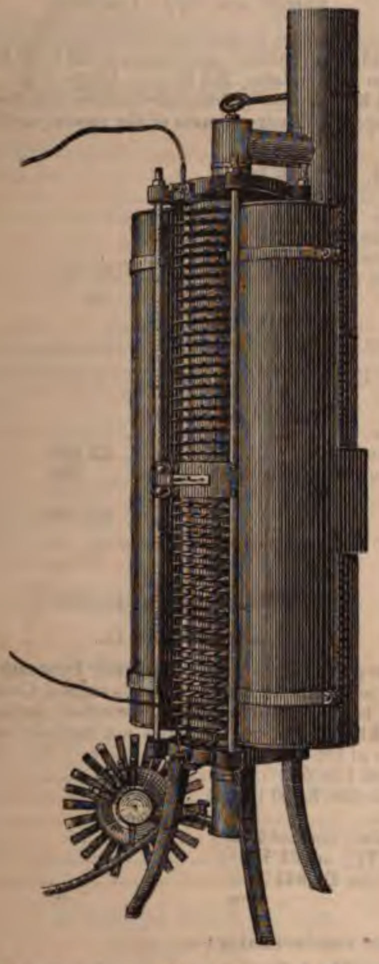
For many years it has been the endeavour of electricians to devise an electric generator which, by its construction or combination, should not only surpass those in use by its simplicity, but also at the same time render possible the transformation in the most simple manner of a given amount of heat into electrical energy—in short, that the whole requirements both of manufacturers and of private persons in this respect might be completely satisfied. There is no doubt that the direct transformation of heat into electricity may give us in the near future the possibility of the production of electrical energy in the simplest, cheapest, and most practical method; therefore it would be both desirable and of great material profit if an equal importance were laid upon the improvement of thermo batteries, as lately has been given to dynamos.

A decided advance has lately been made in this province by the novel construction of a thermo battery by E. Raub, of Berlin. It is of considerable importance, because in it

* Abstract of paper in *Centralblatt für Electrotechnik*, No. 7, 1888.

all the defects pertaining to the old thermopile are overcome, and also because both the smallness of the cost of maintenance renders it applicable for many technical purposes, especially electro-plating, and the comparative ease of manufacture enables it to be produced at a very small first cost.

As is seen in the accompanying figure, the battery consists of two principal parts—1, the ring-shaped elements, and through them the corresponding heat channel; 2, the cooling arrangement, which, insulated, surrounds it. The corona standing behind the tripod in the figure, shows a single element; the positive electrode, formed of a metal alloy, is cast in the form of a ring round a copper "heat ring." By this means a particularly strong and intimate connection is formed. The "cold ring" surrounds this, outside a second copper ring with radiating cooling lobes. The negative metal, which is hard soldered with sheet tin to the heat ring in such a manner that local currents at the points of contact are entirely avoided, is soldered, after the elements are laid one



upon the other, to the cooling lobes of the next element. A number of similar thermo-elements of any desired dimension are fastened together between two cast-iron plates by means of four iron rods with screws and nuts, and well insulated from each other with fire-proof material; the single-element rings stand centrally over each other, forming a strong and secure hollow cylinder, which serves as a heat chamber. The heat can be obtained from any suitable source. For the smaller apparatus, such as is shown in the figure, a ring-shaped Bunsen gas-burner is sufficient. For larger sizes, a coal or coke fire is required. The burner is screwed to the lower end of the built-up heat channel, and the flame impinges upon the heat rings of all the elements at the moment it unites with the oxygen. The heat is distributed equally on all the elements by means of a slender cone fastened to the top of the heat chamber and projecting inwards, which goes through into an angle-pipe to a wide stove-pipe; this is closed at the bottom, screwed to the tripod, and communicates with a chimney having a good draught. The heat ascending in the chimney draws up fresh air, not only through the lower part of the mouth of the heat channel, but also through air tubes brought into the principal pipe, well insulated outside, and pressing against the elements, so that the outer contact points of the ring elements are kept cool by the air draught. A damper for regulation of the draught is advisable.

The use of ring-shaped elements in connection with this forced air draught permitting the greatest possible development of heat, as well as the production of the greatest possible difference of temperature, produces a very economical arrangement; in it is combined a battery quickly and easily set in action, taking up a very small amount of room, at the same time susceptible of being heated with ordinary gas, and easily mounted on a stand. The durability and strength of the elements is a great advantage, together with the ease with which damaged rings can be taken out, either for repair, or for insertion of new ones, which are to be obtained singly from the makers.

For electro-deposition of metals, electrolysis, &c., the three smaller sizes, gas-heated, are most applicable; these consume 300, 500, and 900 litres of gas per hour, giving a current of 10, 20, and 40 amperes, with an E.M.F. of 3 volts. With a consumption of 1 cubic metre of gas per hour, these batteries produce a return of 80 volt-amperes, while older-known constructions give at most 27 volt-amperes.

CHELSEA.

The report of the surveyor to the vestry, Mr. Geo. R. Strachan, on the lighting of the Town Hall buildings with electric light, shows that ten electric lighting companies were asked to give estimates of the cost for providing plant, &c., for doing the work. For the guidance of the contractors the following standard of light was given :—

Town Hall	320 candle-power
Council Chambers	350 ,,

The light in the platform ante-room, the tea-room, the lower hall, and the main corridors was to be in the same proportion as what has just been given; in all other matters the firms were allowed a free hand. The whole of the firms invited sent in tenders; eight of them proposed a separate installation, while two, in connection with local companies, proposed to supply from a central station. Messrs. Drake and Gorham included in their tender a duplicate set of engines and dynamos; the other firms included accumulators in their estimates, or expressed the opinion that they should be provided. Messrs. Crompton and Co. estimated for providing new electroliers and fittings throughout, but the others estimated for combining the electric light fittings with the present gas fittings. The local companies proposed to have an accumulator, and supply the current by a meter. The prices for which a separate installation was offered vary from £1,935 to £800, but, as Mr. Strachan so ably points out, these figures form no guide whatever to the determination as to which tender is the most desirable. The study of them resolves themselves into a question of what is not included in the sum. Some include accumulators, some fittings and electroliers, some exclude wiring, building, and contractors' work, foundations for engines, &c., and having these things in mind, Mr. Strachan reduces the tenders as far as possible to a standard.

The firms each supplied an estimate of the annual cost per year for the maintenance of a thousand hours a year, and the estimates vary from £558 to £246. The estimates for this cost of maintenance are not comparable. Thus, one firm includes £182 a year for labour, &c.; another does not include this item, but calls attention to the necessary addition to the estimate. One firm puts the lamps renewal at £90, another at £10. One firm estimates the life of the lamp at 2,000 hours; another at 1,000 hours. One firm puts coal at 20s. per ton; another at 16s. per ton. One firm allows £150 for depreciation, while another allows £36. As Mr. Strachan says, "It is impossible to reconcile these differences—they are as amusing as they are perplexing," and he therefore made no attempt at standardising. These calculations show, taking all things into consideration, the total cost of gas to be ·19d. per 16-candle power per hour; the cost for comparison with the electric light is taken at ·15d. per 16-candle power per hour.

The following is a table of the annual cost of the systems tendered for when the estimates have been standardised by Mr. Strachan as well as able:—

	Annual cost.				Cost of 16 c.-p. per hour.
Chelsea Electricity Supply Co.	£583	7	0	...	·467
Cadogan Electric Light Co.	536	8	4	...	·429
Drake and Gorham	516	5	6	...	·413
Siemens Brothers and Co.	502	7	0	...	·402
Edison, Swan and Co.	483	11	0	...	·395
Crompton and Co.	462	4	0	...	·369
Mr. Ronald Scott	453	15	0	...	·363
Smith and Co.	450	13	0	...	·361
The Anglo-American Brush Co.	444	5	0	...	·355
Holmes and Co.	440	14	0	...	·353

It may be taken that the cost by a separate installation will be from $2\frac{1}{3}$ times to $2\frac{4}{5}$ times the cost of gas, and the cost from a central station will be three times that of gas.

The following were the estimates sent in by the selected firms:—

Chelsea Electric Company.

This company proposes to supply the current from a central station, and to charge for the electricity by meter. Their estimate for providing conductors, wires, casings, switches, cut-outs, 8 circuits, 291 16 c.-p. incandescent lamps, and plain electric fittings, is £507 10s. They propose to supply the current at 8d. per Board of Trade unit, which is between ½d. to ⅓d. per 16 c.-p. per hour. The company has not a central station yet. They estimate the annual cost, allowing 1,000 hours for the life of the lamps, at £543 4s. This estimate standardised is:—

	£	s.	d.
Lamps and current	£543	4	0
Interest on £507 at 4%	20	3	0
Depreciation on fittings	20	0	0
	£583	7	0

or ·467d. per 16 c.-p. per hour.

Cadogan Electric Company.

This company proposes to supply the current from a central station, and to charge for the electricity by meter. Their estimate for providing conductors, wires, switches, cut-outs, six circuits, 235 16 candle-power lamps, adapting the gaseliers to the electric fittings, &c., is £566 19s. They would provide and keep in order at their own cost an accumulator to hold current for six or seven hours. The charge for the current will not exceed 7d. per Board of Trade unit, which they say is as near as possible ⅓d. per 16 candle-power per hour. (According to the usual means of calculating the cost, the price would have to be less than 7d. per unit to reduce the cost to ⅓d. of a penny per 16 candle-power lamp per hour.) The annual cost would be:—

				£	s.	d.
300 lamps for 1,000 hours each, at ⅓d. per lamp per hour				£426	13	4
Depreciation				20	0	0
Interest at 4% on	£566	19	0			
Add to make up to 300 lamps	83	1	0			
	£650	0	0	26	0	0
Lamp renewals				63	15	0
				£536	8	4

or ·429d. per 16 c.-p. per hour.

Drake and Gorham.

This firm proposes to provide a duplicate plant without accumulators. Their estimate for two 12 horse-power Marshall engines with boilers, two Worthington pumps, two Elwell-Parker dynamos, two driving belts, 306 16 candle-power lamps, switchboards, switches, cut-outs, wires, &c., is £1,935 9s. The estimate does not include builders' work, structural alterations, or ornamental fittings. Their estimate of the annual cost is:—

	£	s.	d.
Coal, 86 tons at 16s.	£68	16	0
Water, oil, waste, &c.	19	0	0
Depreciation	75	0	0
Lamps (life 1,500 hours)	40	0	0
Interest (4% on £2,000)	80	0	0
Labour, £2 per week	104	0	0
	£386	16	0

The estimate standardised is:—

		£	s.	d.
Coal, 86 tons at 20s.		£86	0	0
Oil		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£1,935			
Add for omitted works	400			
	£2,335 at 7½ %...	175	2	6
Interest on ditto at 4%		93	8	0
		£516	5	6

or ·413d. per 16 c.-p. per hour.

... and Co.

... Their

lator, builders' work, an engine-house, &c., in the ... estimate of the annual cost is:—

	£	s.	d.
Coal, 60 tons at 20s.	£60	0	0
Oil, waste, &c.	12	0	0
Interest, 4%	65	12	0
Depreciation, 10% on £800	80	0	0
Do. 5% on £750	37	10	0
One set of lamps, £90	90	0	0
Repairs, 2½% on £800	20	0	0
	£365	2	0

Their estimate standardised is:—

		£	s.	d.
Coal, 60 tons at 20s.		£60	0	0
Oil		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£1,640			
Add for omitted works, &c.	800			
	£2,440 at 7½%	183	0	0
Interest on do. at 4%		97	12	0
		£502	7	0

or ·402d. per 16 c.-p. per hour.

Edison and Swan Company.

This company proposes to generate the current by gas power. Their estimate for a 14 h.-p. "Otto" gas engine, a 220 light Edison-Hopkinson dynamo, an accumulator, 263 16 c.-p. lamps, wires, switches, cut-outs, &c., is £1,220. It does not include fixtures, structural alterations, gas or water supply. Their estimate of the annual cost is:—

	£	s.	d.
Attendance	£78	0	0
Gas, at 2s. 10d. per 1,000 feet	144	8	0
Oil, waste, &c.	44	0	0
Lamp renewals	42	10	0
Upkeep of accumulators	41	10	0
Upkeep of engine, &c.	18	0	0
Interest, 4% on £1,220	48	16	0
	£417	4	0

This estimate standardised is:—

		£	s.	d.
Gas, at 2s. 5d. per 1,000 feet		£124	0	0
Oil, &c.		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£1,220			
Add for omitted works, &c.	500			
	£1,720 at 7½%	129	0	0
Interest on do. at 4%		68	16	0
		£483	11	0

or ·395d. per 16 c.-p. per hour

Crompton and Co.

This firm proposes to generate its current by steam power. Their estimate for a multitubular boiler, Willan's engine, Crompton dynamo, 260 16 c.-p. lamps, cut-outs, wires, switches, indicator, new fittings, &c., is £1,541. 17s. 6d. It does not include an accumulator. Their estimate of the annual cost is:—

	£	s.	d.
Coal, 50 tons at 17s. 6d.	£43	15	0
Lamp renewals (life 2,000 hours)	32	10	[illegible]
Oil, waste, &c.	20	0	0
Labour (half time man and boy)	58	10	0
Depreciation, 7½% on £1,180	88	10	0
Interest at 4% on £1,541	61	13	6
	£304	18	6

This estimate standardized is:—

		£	s.	d.
Coal, 50 tons at 20s.		£50	0	0
Oil, waste, &c.		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£1,541			
Add for omitted works, &c.	637			
	£2,178 at 7½%	163	7	0
Interest on do. at 4%		87	2	0
		£462	4	0

or ·369d. per 16 c.-p. per hour.

The Brush Co.

This firm proposes to use steam power. Their estimate for a 20 h.-p. boiler, brush engine, dynamo, 266 17 c.-p. lamps, cut-out, meters, switch-boards, switches, belt, &c., is £800. It does not include wiring, fittings, builders' work, or accumulators. Their estimate of the annual cost is:—

	£	s.	d.
Coal, 64 tons at 20s	£64	0	0
Water, oil, &c.	15	16	0
Lamp renewals (life, 1,000 hours)	59	16	0
Labour	78	0	0
Interest, 4% on £800	32	0	0

This estimate standardised is:—

Coal		£64	0	0
Oil, waste, &c.		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£800			
Add for omitted words, &c.	1,100			
	£1,900 at 7½%	142	10	0
Interest on do. 4%		76	0	0
		£444	5	0

or ·355d. per 16 c.-p. per hour.

GEORGE SMITH AND CO.

This firm proposes to use gas power for their current. Their estimate for a gas engine, two dynamos, storage batteries, 247 16-c.-p. lamps, wires, casings, &c., complete, is £1,330. It does not include laying gas on to the engine. They call attention to the fact that an attendant will be required. Their estimate of the annual cost is:—

Lamp renewals	£50	0	0
Oil, waste, &c.	8	0	0
Depreciation	54	0	0
Gas	80	0	0
Interest	54	0	0
	£246	0	0

This estimate standardized is:—

Gas		£110	0	0
Oil, waste, &c.		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£1,333			
Add for extra lights	223			
	£1,556 at 7½%...	116	14	0
Interest at 4%		62	4	0
		£450	13	0

or ·361d. per 16-c.-p. per hour.

MR. RONALD A. SCOTT.

This firm proposes to generate its current by steam power. Their estimate for a multitubular boiler, Willan's engine, dynamo, switch board and switches, meters, 200 lamps, fittings, cut-outs, wires, &c., is £1,580. It does not include accumulators. The estimate of the annual cost is:—

Stoker and engine driver	£78	0	0
Electrician	104	0	0
Lamps replaced	10	0	0
Oil and waste, &c.	29	0	0
Fuel	62	0	0
Engine repairs	20	0	0
Storage batteries replaced	25	0	0
Interest	80	0	0
Depreciation, 10 % on £1,500	150	0	0
	£558	0	0

This estimate standardized is:—

Coal		£62	0	0
Oil waste, &c.		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£1,580			
Add for omitted works	420			
	£2,000 at 7½ %	150	0	0
Interest at 4 %		80	0	0
		£453	15	0

or ·363d. per 16 c.-p. per hour.

HOLMES AND CO.

This firm proposes to use steam power. Their estimate for a 16 h.-p. multitubular boiler and chimney, Worthington pump, Willan's engine, No. 14 Castle dynamo, 300 16 c.-p. lamps, cut-outs, wires, voltmeter, &c., is £930. It does not include wiring the Town Hall, foundations to boiler and engines, fittings, access for machinery or accumulators. Their estimate of the annual cost is:—

Coal, 57 tons at 16s.	£45	12	0
Lamps (life 2,000 hours)	30	0	0
Oil and waste	10	0	0
Sundry repairs	20	0	0
Interest and depreciation, 8%	72	0	0
Labour, man at 28s.	72	16	0
	£250	8	0

This estimate standardised is:—

Coal, 57 tons at 20s.		£57	0	0
Oil		20	0	0
Labour		78	0	0
Lamp renewals		63	15	0
Depreciation on	£930			
Add for omitted works, &c.	1,000			
	£1,930 at 7½%	144	15	0
Interest on 4%		77	4	0
		£440	14	0

or ·353d. per 16 c.-p. per hour.

ELECTRICAL TRAMWAYS: THE BESSBROOK AND NEWRY TRAMWAY.*

BY EDWARD HOPKINSON, M.A., D.SC., ASSOC. M. INST. C.E.

Although the subject of the application of electricity to locomotion has been much discussed during the last few years, comparatively few attempts have been made at its practical realisation. The first electrical tramway in the United Kingdom, constructed between Portrush and Bushmills, in the north of Ireland, was opened for traffic in October, 1883, and has since been extended. In his lecture before the Institution† in March, 1883, the late Sir William Siemens gave a general description of this line, and the electrical details were further discussed in a paper read before the Society of Arts in April, 1883, by the author.‡ In 1883 Mr. Magnus Volk constructed a line along the foreshore at Brighton, upon which a single car has since been running regularly, and Messrs. Siemens Bros. have a short length of line in operation on the pier at Ryde. On a larger scale is the tramway along the promenade at Blackpool, two miles in length, constructed by Mr. Holroyd Smith. The construction and method of working have been fully described by Mr. Smith, in a paper read before the British Association at the Birmingham meeting, 1886.§ The conductor, as in the before-mentioned lines, is continuous, and several cars are in motion on the track at the same time. The cars are of various sizes, and accommodate from thirty to fifty-six persons. The track is nearly level, and a speed of six miles per hour is generally attained. Mr. Reckenzaun and Mr. Elieson have also done much in the application of storage batteries to tramway work.

In none of these instances has any attempt been made at the regular haulage of minerals and goods, nor at the operation of cars larger than the ordinary tramway type. Probably in no case has the effective power of any single motor exceeded about 4 horse-power. In July, 1884, Mr. Barcroft, of the Bessbrook Spinning Company, whose extensive flax mills and stone quarries are situated at Bessbrook, about three miles from Newry on Carlingford Lough, suggested to the author that the line, which the company had decided to make between Newry and Bessbrook, for the carriage of coal and flax from the wharves to the mills and the down traffic of manufactured goods, might be worked electrically, for which the abundant water-power available offered exceptional advantages. The following conditions were to be met. Ten trains to be run in each direction per day, providing for a daily traffic each way of 100 tons of minerals and goods, and capable of dealing with 200 tons in any single day, in addition to the passenger traffic; the electrical locomotive to be capable of drawing a gross load of eighteen tons on the up-journey, in addition to the tare of the car itself and its full complement of passengers, at an average speed of six miles per hour, and a load of twelve tons, at an average speed of nine miles per hour. The company agreed to place the line entirely at the disposal of the author for a period of time, and to purchase the electrical plant at a fixed sum, when the above conditions had been complied with, and it had been shown that the cost of working, as evidenced by six months' trial, did not exceed the cost of steam traction on a similar line. The work was commenced in November, 1884, and the line opened for traffic in October, 1885, and was formally taken over by the company as having fulfilled the conditions of the contract in the following April. Since that time it has been in regular daily operation.

GENERAL DESCRIPTION OF THE LINE.

The line commences at the Edward-street terminus of the Newry branch of the Great Northern Railway, and runs parallel to it for about ¾ mile; and then, passing through a cutting, follows the course of the Camlough stream, running under the central arch of the viaduct on the main Great Northern line, which crosses the valley at

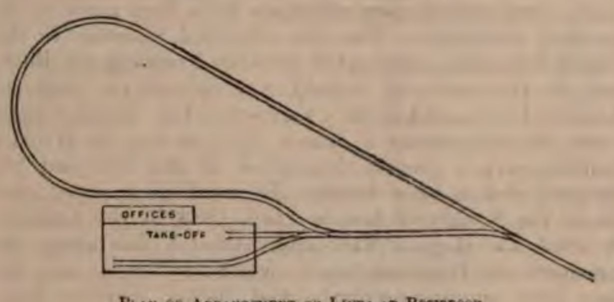
* Paper read before the Institute of Civil Engineers, and reprinted by permission from the *Transactions* of the Institute.

† The Inst. C.E. Lectures on "The Practical Applications of Electricity." Session 1882-83. "The Electrical Transmission and Storage of Power." By Dr. C. William Siemens.

‡ *Journal* of the Society of Arts, Vol. xxxi., p. 531.

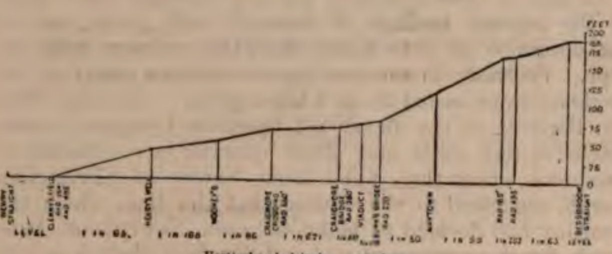
§ See *The Electrician*, September 10, 1886.

a height, in the centre, of 126ft. Near the viaduct is the first station, close to the small village of Craigmore, and an outlying mill of the Bessbrook Company. Proceeding up the valley, with a gradient of 1 in 50, the county road is crossed, diagonally, by a level crossing, 50 yards in length, near which is the second station, Millvale, at which point



PLAN OF ARRANGEMENT OF LINES AT BESSBROOK.
Scale 1 inch = 100 feet.
FIG. 1.

the line crosses the stream, and the turbine and generating dynamos are erected. The line again crosses the stream ¾ mile from Millvale, and thence runs into the terminus at Bessbrook, where a station and carriage shed are erected. The total length of the line is 3 miles 2·4 chains; and the average gradient 1 in 86, the maximum gradient being 1 in 50 (Fig. 1). The gauge is 3ft. and the rails are at present single, but land has been acquired for a double line. At each terminus is a loop of 55ft. radius (Figs. 2 and 3), so that the cars do not need reversing, except in coupling

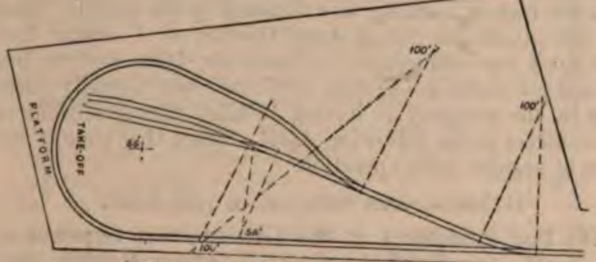


Vertical scale 1 inch = 200 feet
Horizontal „ 1 „ = 4,000 „
FIG. 2.

up the waggons or shunting in the sidings. The permanent way has been laid out and constructed under the supervision of Mr. J. L. D. Meares.

LOCOMOTIVE EQUIPMENT.

The locomotive equipment of the line consists of two passenger cars, 33ft. and 21ft. 8in. long respectively, each provided with a motor. The body of the car is carried on two four-wheeled bogies with a wheel-base 4ft. 6in., the motor being carried on the front bogie independent of the body of the car (Fig. 4). This arrangement



PLAN OF ARRANGEMENT OF LINES AT NEWRY.
Scale 1 inch = 100 feet.
FIG. 3.

enables the cars to traverse the 55ft. curves at the termini with great facility, and also relieves the body of the car from the vibration due to the driving. The body of the longer car is divided into three compartments—the front one covers the motor; the second forms a second-class compartment, seating twenty-four passengers; and the third, a first-class compartment seating ten passengers, separated from the second by a cross-passage. The front bogie carrying the motor has an extended platform, projecting 3ft. 7in. beyond the body of the car, and communicating by a slide-door with the dynamo compartment, thus giving the driver direct access to all parts of the driving machinery, which are at the same time entirely boxed off from the passenger compartments. All four wheels are braked by a powerful screw-brake worked from the front of the driving platform, on which is also fixed the switch-board controlling the motor. The wheels of the back bogie are braked by a chain-brake worked from the cross-passage, and are under the control of the conductor. This brake is also prepared for coupling to the waggons. The total weight of the car is 8¼ tons, distributed as follows:—

	Tons.	cwt.	qrs.
Car body	3	6	1
Leading bogie	1	17	2
Trailing	1	0	0
Dynamo, bed-plate, armature and accessories	2	1	1
	8	5	0

The shorter locomotive car is similar, but without the first-class compartment. Both cars were built by the Ashbury Carriage Company, of Manchester. There is also a third passenger-car of the same length as the first, and accommodating 44 passengers, and similarly carried on two four-wheeled bogies. This car weighs 5½ tons, and was constructed by the Starbuck Company, of Birkenhead.

THE USE OF WAGGONS WITH FLANGELESS WHEELS.*

Apart from the electrical working of the line, an important and novel feature is the plan by which the waggons used on the line can also be used on the ordinary public roads, so avoiding the necessity of transhipment, and enabling goods to be loaded at the wharves and drawn to the line by horse-power, and again delivered at any part of the mill premises. The plan was originally suggested in 1880 by Mr. Alfred Holt, M.I.C.E., of Liverpool, and was embodied in the Lancashire Plateways Scheme, for which a Bill was lodged in the autumn of 1882, and subsequently withdrawn. The idea has been worked out in a practical form with great success by Mr. Henry Barcroft, of Newry, one of the directors of the company. The wheels of the waggons are constructed without flanges, with tires 2¾in. wide, which is sufficient for use on ordinary roads (Fig. 5). Outside the tramway rails, which are of steel, and 41·25lb. per yard section, second rails are laid, having a section of 23·75lb. per yard, with the head ⅝in. below the head of the larger rails. The flangeless wheels run upon these lower rails, the ordinary rails forming the inside guard (Fig. 6). The wheels are loose on the axles; but the latter are not fixed, but are carried in journals, so that there is freedom in both wheel and axle, which considerably reduces the friction, especially in travelling round curves. The front part of the waggon is supported on a fore-carriage, which can either be pinned or allowed freedom of motion, as in an ordinary road vehicle (Fig. 4). The buffers are fixed on the truck-frame, and no buffing is done against the fore-carriage. There is a single central coupling arranged to engage in a jaw in the fore-carriage, so as to guide it when not pinned. Shafts are attached to the fore-carriage when the waggon is to be used on the ordinary roads. The weight of each waggon without the shafts is 23¼ cwt., and the waggons are of sufficient strength to carry a load of two tons. This load is not too much for a single horse on roadways where there are no steep gradients; on steep gradients two horses are required. The double line of rails is not continued round the curves at the termini, but a take-off is arranged (Figs. 2 and 3), into which the waggons are run by the car. The shafts are then affixed, and the waggons drawn off by horses. Twenty-two of these waggons have been supplied to the Tramway Company by the Ashbury Carriage Company, and have been in constant use for eighteen months. Experience has shown that the wear and tear, both on the wheels and rails, is not excessive, and that the traction does not much exceed, if at all, that of ordinary trucks with

* Illustrations of these Waggons (Figs. 4 and 5) will be given with the continuation of the article.

flanged wheels. No difficulty has been found with the horse traction on ordinary roads, and the taking on and off is conducted with great rapidity. The utility and wide applicability of this plan are obvious, and it may do much to develop the introduction of short tramways where the cost of transhipment would be fatal to the ordinary methods of working.

HYDRAULIC AUTOMATIC GATE-OPENER.

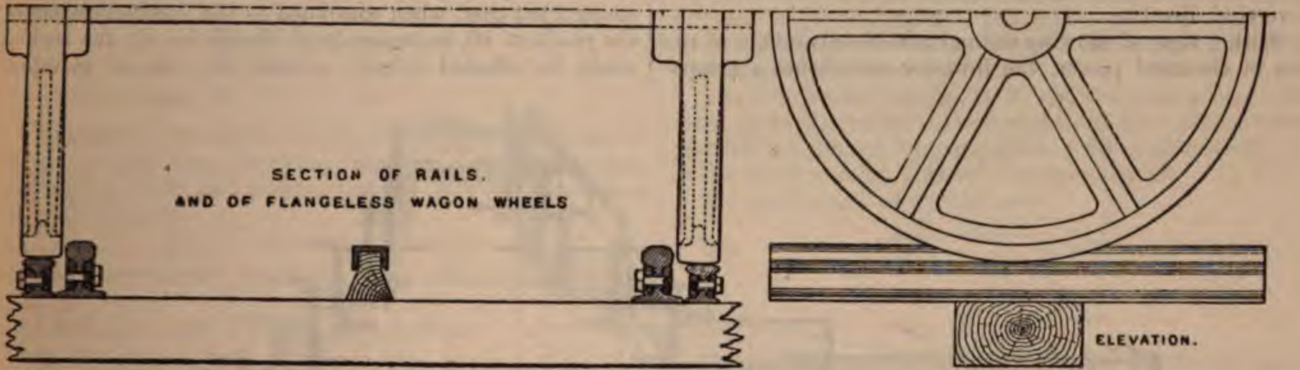
Another novel device introduced by Mr. Barcroft is an automatic hydraulic apparatus for opening the gates protecting the level crossing of the county road. The regulations of the Board of Trade require that gates should be provided at such crossings, and that they should be closed immediately after the passage of the train. To avoid the cost of a gateman, the following plan has been adopted. As the locomotive car approaches the crossing at a distance of about 50 yards, a suitable arm attached to the foot-board strikes a lever pivoted on one side of the permanent way, and turns it over. The lever is connected with a three-way cock, which, when opened, withdraws the water from a cylinder provided with a float. To this float a wire rope is attached, which opens the gates on both sides of the crossing as the float sinks in the cylinder. After passing the crossing, the car strikes a second lever similarly situated, and connected by a second wire rope to the three-way cock. When the lever is thrown over, the cock is turned so as to admit water from a cistern placed at a higher level into the cylinder, raising the float and closing the gates, the float being assisted by a balance-weight attached to each gate.

GENERATOR STATION.

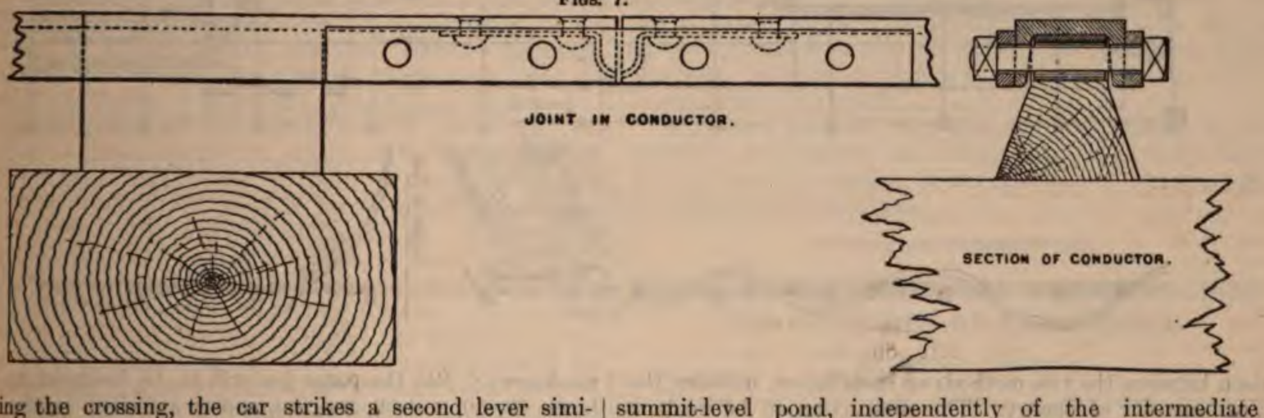
The generating machinery is fixed at Millvale, a distance of 68 chains from the Bessbrook terminus. At this point, in close proximity to the line, there is an available fall of 28ft. in the Camlough stream, down which there is a guaranteed minimum flow of 3,000,000 gallons per day. The turbine is an inward-flow vortex wheel with double buckets, working on a horizontal shaft extended into the dynamo shed, from which the dynamos are driven direct with belts. The capacity of the wheel is 1,504 cubic feet per minute, and when running at 290 revolutions per minute should develop a maximum power of 62 h.-p. It is worked with a tail draught of 13ft. The admission of water is controlled by a shutter-valve regulating the flow uniformly through each bucket of the wheel, and actuated either by hand or by a centrifugal governor. The latter is not direct acting, but as its balls rise or fall beyond certain limits, couples one of a pair of right and left-hand bevel wheels driven by a wheel on the governor-spindle to a small countershaft, geared with the valve-spindle.

(To be continued.)

FIGS. 6.



FIGS. 7.



THE ELECTRICAL TRANSMISSION OF ENERGY FOR THE FEEDING OF CANALS.*

The novel application of the electrical transmission of energy for the supply of water to canals having reaches at different levels, and especially lock canals, has recently been designed by M. Edmond Henry, a former pupil of the *Ecole Polytechnique.*

Of the different varieties of canal, those known as canals with dividing ridge *(à point de partage)* offer the greatest difficulties of feeding. The upper reach in the vicinity of the summit line receives from water courses a minimum supply for this reason, in the greater number of existing canals the height of the summit-level pond has been made dependent upon the feeding with detriment to economy. In certain cases use is made of natural ponds, or separate reservoirs and feeders are constructed for the supply of the summit-level pond, independently of the intermediate reaches.

Canals which are fed by means of steam or hydraulic machines, such as that from the Aisne to the Marne, and that from the Marne to the Rhine, are those which lend themselves most readily to the application of the electrical transmission of energy, combined with the use of natural hydraulic power. In most canal schemes the latter may be found without much difficulty, but its employment may be difficult or of little advantage if the difference of altitude of the motors and of the upper reaches, and the distances to be traversed, are considerable. If pumps worked by turbines are utilised for the object in view, a very costly conduit, involving great resistance, is requisite for forcing the water to the upper reach of the canal; moreover, this water must be taken by the pumps at the level and in the vicinity of the motors, and then raised through the whole difference of level to the summit-level pond.

In the electrical system proposed by M. E. Henry, instead of having to force the water from the hydraulic machine works, by means of a costly canalisation, to the inlet of the summit-level pond, it is possible to bring the water through feeders to an intermediate reach which can be naturally

* Translated from the *Revue Industrielle.*

supplied, and from this to raise it to the successive levels, and ultimately to the upper reach. This arrangement dispenses with all canalisation; the pump-shafts will thus have at each point only the length corresponding to a lock, and loss by leakage will no longer have any importance.

The canalisation is here replaced by conducting wires carried on posts like telegraph lines. In this way the expense and the time requisite to establish an installation are considerably reduced.

The installation is thus composed of hydraulic machine works, in which are driven the transmitting dynamos; the wires connected to which transmit to a distance the energy for working other similar dynamos—the motors. The latter are directly connected with various sets of pumps, either rotary or with piston, which have only to raise the water through the height of a lock, taking it from the end of one reach to the adjacent extremity of the next in altitude. Under certain circumstances, the electrical power could be employed for the lighting of the canal, for transmission of power to a given point, or for haulage purposes.

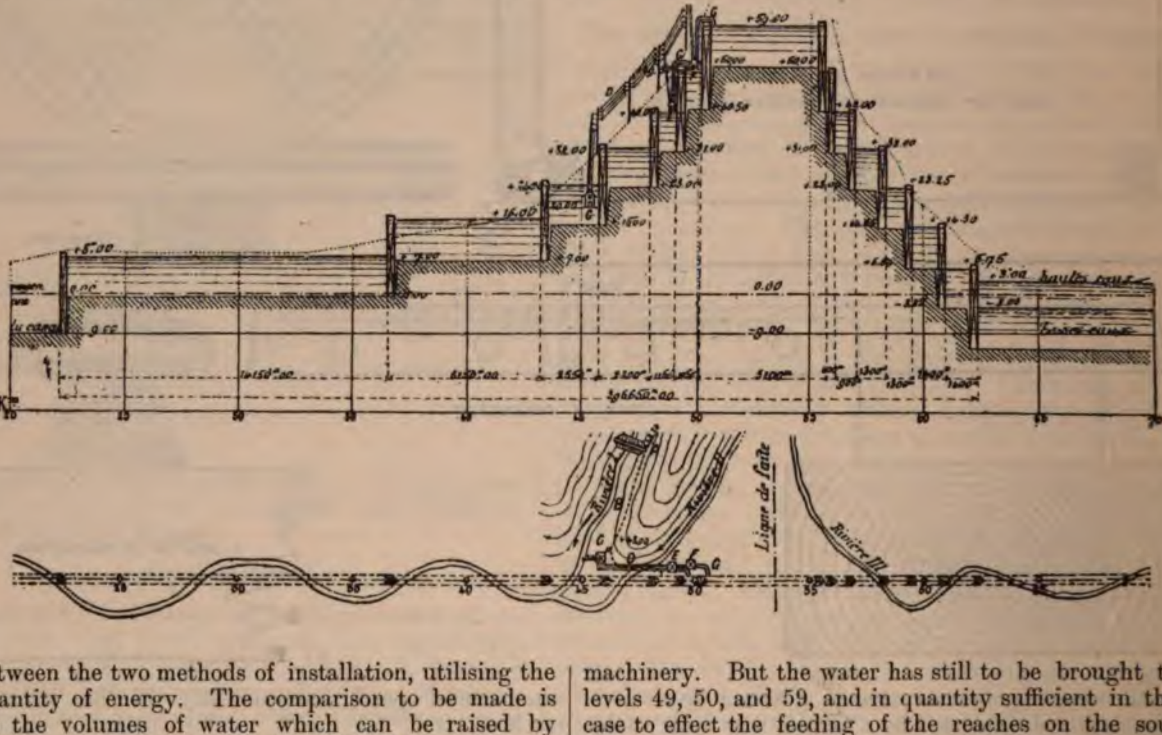
One of the main advantages of the use of electricity in conjunction with a system of force-pumps consists in the fact that the loss of energy in the conducting wires, and, consequently, the efficiency, does not vary for a given distance of transmission, whether this distance be in a horizontal or a vertical direction.

With a view of showing the indubitable advantage of the use of electrical power, the inventor establishes a compa-

III., or from a reservoir obtained in the valley of river I. by the construction of a slight dam. The rivers II. and III. supply to low-water mark 2·5 metres per second, which can be brought to the summit-level pond. River I. has a rate of discharge to low-water mark of 26·5 metres per second, and will give, without very great expenditure in works, a fall of 22 metres, which, utilised in hydraulic machines—turbines with horizontal axis, Girard system—represents theoretically 7,773 h.-p. Only 19·23 metres of the discharge are taken; so as to obtain a motive power of 5,640 horses. The remaining 7·27 metres are conducted directly to the reach on the incline 40.

This charge of 22 metres can be obtained by constructing a slight dam in the valley of river I., which will produce an accumulation in the direction of 44, whence the waters can be conveyed to the point marked on the plan where the hydraulic motors are installed.

Feeding of the Different Reaches.—The power developed by these motors may be utilised in various ways for conveying water to the various reaches of the northern side as well as to the summit-level pond; for those on the northern side are fed by means of the latter. The various reaches of the north side, in the scheme considered, have their water levels respectively at 8, 16, 25, 32, 40, 49, 50, and 59. Consequently, if the trench from the valley were so constructed that, when continued to the commencement of the reach at 40, its water level should be 41, the feeding could be effected directly without the use of elevating



rison between the two methods of installation, utilising the same quantity of energy. The comparison to be made is between the volumes of water which can be raised by each system to the summit-level pond. Taking into account, however, the somewhat low efficiency in the electrical transmission of power to a distance, it should be observed that this latter means does not allow of the water being raised to as great a height as with the system of pumps and conduits; and, therefore, the comparison should be made in each particular case by taking into account the distance of transport and the height through which the water has to be raised. In the example given below, which is cited by M. Henry, it will be seen that the efficiency by volume may be more advantageous in the case of electricity. The data of the application are analogous to those which would occur in practice.

We will suppose that a canal is to be established according to the section and plan shown in the accompanying sketch, and that the district is mountainous, with steep inclines in the valleys. It is easy to calculate the expenditure of water in working, as well as the loss by evaporation and infiltration. In the present case it is estimated that each vessel of large tonnage requires 120,000 cubic metres of water for its passage from one level to another.

A certain supply of water which can be brought to the canal is obtained either from the neighbouring rivers II. and

machinery. But the water has still to be brought to the levels 49, 50, and 59, and in quantity sufficient in the last case to effect the feeding of the reaches on the southern side.

The figures and conclusions arrived at by M. Edmond Henry are as follows:—

Feeding of the Reach at the level 59 by Hydraulic Motors and Pumps.—The machines placed at the level 20 receive the water which gives the motive power (19·23 c.m. per sec. with a fall of 22m.) through a supply trench, having a fall of 0·10m. per kilometre, flowing into an iron tower 25m. high, sunk in the slope of the adjacent hill in the same manner as a tubular pier, from the foot of which proceeds the conduct carrying the water to the turbines. This tower, which answers the purpose both of a charging column and a reservoir, would be from 12 to 15 metres in diameter. This conduct, from the configuration of the ground, would be about 200 metres long, and would be laid either in a covered or an open way.

The machines thus receive a quantity of water representing

$$\frac{19 \cdot 23 \times 22}{7 \cdot 5} = 5640 \text{ h.-p.}$$

The force-conduit of the pumps, which has to be taken to kilometre 50·5, starting from a point opposite kilometre

puzzle even an expert watchmaker to remove. The advent of electricity in its modern and manifold branches of utility has forced upon us the importance of this question: How can we prevent this magnetism from gaining a damaging influence upon our watches? or, if not prevented, how can we best and most speedily repair the damage done?

Let us not look upon the question lightly, but rather in all earnestness. Let us bear in mind that, while the powerful dynamo in the engine-room of the manufactory, the business house, or the ocean steamship, sends forth its currents through many lines to furnish light or power, it sends forth also a very different influence, and one that makes mischief with the watch carried by the engineer or electrician, the visitor to the works, or the captain, or the pilot who may happen to approach for a moment within the influence of such a dynamo. Let us not forget that, in the latter event, serious results may follow, for, by the captain's chronometer, in conjunction with the compass, the great ship is sailed. We should bear in mind that, in the manufacture of our best watches, the object of the maker is to confine in the smallest space possible the greatest strength and durability. In order to accomplish this object he finds it necessary to use, for the principal parts of the watch, hardened steel, a material decidedly susceptible to the influences of magnetism. The hair-spring and the balance-wheel, vital parts of the watch, are thus frequently constructed; and even though the balance be made of a combination of metals, the steel in the little points on the wheel may be attracted to the little steel screws necessary to perfect firmness in the larger mechanism of the watch; for these screws may be readily charged with magnetism of sufficient force to be long retained and to exert a continual influence over the other magnetic matter. The escapement-wheel—likewise of steel if durability be desired—becomes easily magnetised also, and its movement is seriously retarded. Then the hair-spring, with its delicate coils close together, may be so polarised that the coils on the side next to the nearest steel screw will all adhere to each other, and play havoc with the motion of the watch.

Thus our very best timepieces are most susceptible to the influence which may, and often does, retard them to the extent of several hours a day.

In my work as an investigator of this subject, which has extended over a period of several months, I have formed three separate solutions of the problem: First, to have the watch made of material that cannot be magnetised; second, to enclose the works in an iron case, so as to shield the vital parts of the watch; and third, to apply efficient means to demagnetise the watch that has not been favoured with the safeguards.

With regard to the first solution, I have had occasion to experimentally test its efficiency. I have applied the most complete magnetic tests to watches made by a well-known watch company, which were claimed to be perfectly free from all magnetic influences. The hair-spring and balance-wheel of these watches are made of an alloy of palladium. I have no hesitation in saying, after subjecting these watches to the strongest magnetic influence in the Westing house Electric Works, that their claim to recognition as non-magnetic timepieces is fully sustained. I have had one of these watches perfectly timed to run with another, and subjected the two to opposite extremes as regards magnetism, yet discovered no deviation in their time-keeping. The one was wholly free from the magnetic influence; the other was running at a point between the pole pieces of a most powerful magnet. I have watched both of them closely for weeks, without being able to detect any difference in their time.

Taking the hair-spring and balance-wheel from a watch, I have placed them upon a little cork float in the water, and then approached them with a most powerful magnet, without being able to detect the slightest motion of the little float or its burden; whereas the ordinary steel hair-spring and balance-wheel, subjected to a similar test, were so strongly attracted that they not only moved the cork float, but jumped from it to the magnet instantly.

While it is true that the screws and a large portion of the other mechanism in these watches are made of steel, yet all the delicate movements in the works are so entirely non-magnetic that, although the steel parts should be charged with magnetism to the highest degree, there would be no perceptible effect exerted upon the running of the watch.

Concerning the second solution of the problem—that is, shielding an ordinary watch against magnetic influences by enclosing it in an iron case—I would say that I have not personally experimented with them; but acquaintances of mine, entirely competent to do so, have given me an excellent idea as to what such watches are capable of. Watches in such case have been very successful in resisting the ordinary influences of the dynamo room. But I would not advise that they be exposed to the influence of very strong fields, because, in that case, they would be magnetised and lose time.

Now for the third solution of the problem. Since it is true that comparatively few non-magnetic watches are in use, and that there are a great many of the ordinary watches with steel works, the question comes up naturally: How can we best demagnetise the watches if they have become injuriously magnetised?

An old way of doing this was in placing the magnetized timepiece in close proximity to a dynamo, then revolving the watch rapidly by means of some mechanism, and slowly removing it from the magnetic influence. This is a very unreliable cure at best, and in many instances quite ineffective. A much better method has presented itself to me. I had occasion recently, while constructing instruments for the alternating current, to observe some facts in connection with this kind of current and its peculiarities, which were suggested to me as being entirely available for use in the process of demagnetising watches. In sending an alternating current through a solenoid, without breaking the circuit in the latter, I found that the steel core had lost its magnetism entirely. Magnetising the core as strongly as I might before this operation, it would be, as I discovered, entirely demagnetised after submission to the process described. Then I found the same proposition to be equally true as applied to a whole handful of steel particles. They might adhere to each other ever so strongly before the operation; but if I endeavoured to pick one of them out of the solenoid with the circuit undisturbed, the steel particle would come out entirely alone, wholly demagnetised and free from attraction to the others. Then I tried a watch whose steel pieces were thoroughly charged with magnetism, and I found that the same process exerted the same effect upon the watch as upon the steel core or upon the many particles of adhering steel. It was utterly demagnetised in all its parts, perfectly cured of its magnetic ailment. It would be unsafe to bring such a perfectly restored watch again within the influence of magnetism unless the owner be desirous of again resorting to the still reliable process described. The solenoid need not be described to electricians. It is a very simple contrivance filled almost to the top with soft iron wire, leaving just room enough at the top, if designed for the purpose described, to allow the insertion and removal of the watch in the manner noted. Any person can apply the test successfully, and if it be in a jeweller's store, or any other place lighted by incandescent lamps supplied for alternating current, the person need only remove the lamp from its socket, insert an attachment plug in its stead, connecting the current with such a solenoid, dip the watch in the hollow end of the solenoid, and, after leaving it in there a while, remove it without disturbing the circuit. In this way a perfect cure for magnetised watches might be applied in any store, factory, or other establishment having alternating incandescent lighting plant. In conclusion, I have only to say that the first solution of the problem described above, namely, that of getting perfectly non-magnetic watches, is the best and safest one for those whose timepieces are liable to be subjected to magnetic influences. I may also add that the third method or cure described demonstrates the wonderful resources of the alternating system of electricity, which, though it may work damage like other systems, has yet within its own qualities a perfect curative power, which cannot be claimed for the continuous or direct current.

PROVISIONAL PATENTS, 1888.

MARCH 31.

4844. **Improvements in or relating to holders for incandescent electric lamps, by which they are made applicable as combined holders and circuit closers and breakers.** William Phillips Thompson, 6, Lord-street, Liverpool. (Napoléon Eusèbe Garczynski).

4875. **Improvements in machinery for raising and lowering submarine telegraph or other cables.** Alexander Wilson and John Forwood Tafe, 3, Elm-court, Temple, E.C.

APRIL 3.

4929. **Improvements in magneto-electric generators.** Webster Gillett and George Haseltine, 52, Chancery-lane, London. (Complete specification).

4940. **Improvements in and relating to alternating current dynamo-electric machines.** Thomas Parker, 70, Market-street, Manchester.

4945. **Improvements in the method of coupling together alternate current electric machines.** C. Faraday Proctor, 46, Lincoln's Inn Fields, London, W.C.

4964. **Improvements in apparatus for the changing and regulating of electric currents.** Alfred Julius Boult, 323, High Holborn, Middlesex. (Stefan Doubrava, Austria). (Complete specification).

APRIL 4.

5029. **Generation of electricity by tidal or river power.** Alfred Henry Mobsby and Alfred Foster Davies, 15, Great St. Helen's, London.

APRIL 5.

5069. **A combined mechanical and electro-magnetic motor.** Charles Adams Randall, 7, Alfred-street, Montpeler-square, West Brompton, London.

5082. **Electricity meters.** Robert Percy Sellon and Robert Cattley Jackson, 47, Lincoln's Inn Fields, London.

5098. **Method of and apparatus for electrical signalling or announcing in connection with telephone circuits.** Pierre Leon Krieboom, 28, Southampton-buildings, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

APRIL 26, 1887.

6104. **Improvements in electrical measuring instruments.** Arthur Le Neve Foster and Frederick Vilhelm Andersen, 156, Strand, London, W.C.

APRIL 28, 1887.

6219. **Improvements in or connected with induction apparatus and the use of it in studying dynamo electric machines.** James Swinburne, Shona, Chelmsford, Essex.

MAY 17, 1887.

7184. **Improvements in electric arc lamps.** William Mackie, Turks Head Yard, Turnmill-street, Middlesex.

JUNE 1, 1887.

7950. **Improvements in or connected with telephones for indicating and recording the number of times that a telephonic instrument is used for ascertaining payments due or for other purpose.** David Johnstone Smith and Hubert Feilden Jackson, 47, Lincoln's Inn Fields, London, W.C.

JUNE 7, 1887.

8159. **Improvements in effecting electric telegraphic communication, applicable especially for telegraphing to lighthouses, either floating or on rocks at a distance from the shore, or for telegraphing to and from vessels.** Willoughby Smith, 24, Southampton-buildings, London, W.C.

AUGUST 2, 1887.

10,659. **Improvements in converters.** William Phillips Thompson, 6, Lord-street, Liverpool. (Gustave Louis Robert, France.)

FEBRUARY 13, 1888.

2179. **Improvements in incandescent electric lamps.** Marshall Wheeler, 18, Buckingham-street, Strand, London.

FEBRUARY 14, 1888.

2246. **Improvements relating to dynamo electric machines.** Henry Harris Lake, 45, Southampton-buildings, London, W.C. (Rudolf Eickemeyer, United States.)

2250. **Improvements in printing telegraphs.** Jacob Hayes Linville, 24, Southampton-buildings, London, W.C.

FEBRUARY 15, 1888.

2308. **Improvements relating to dynamo electric machines.** Carl Coerper, 45, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1887.

3158. **Giving currents of electricity for coin, &c.** P. Everitt. 8d.
4369. **Detecting and measuring electric currents.** P. Jolin. 8d.
4635. **Telephonic, &c. call apparatus.** C. L. Baker and F. Bryan. 8d.
5140. **Galvanic batteries.** W. H. Quarterman. 8d.
5193. **Generating, &c., electricity.** G. A. Grindle. 8d.
6267. **Lock switches for electric circuits.** A. C. Cockburn and E. Thomas. 8d.
6590. **Magneto-electric cut-out.** W. H. Scott and E. A. Paris. 6d.
6621. **Electromotors.** J. D. F. Andrews. 8d.
6624. **Holophotal projectors.** J. G. Statter and S. L. Brunton. 8d.
5933. **Insulating and laying electrical conductors, &c.** D. Nicoll. 8d.
7548. **Transmission through submarine cables, &c.** J. Gott. 8d.
7611. **Submarine cable grapnels, &c.** W. C. Johnson and S. E. Phillips. 8d.
7675. **Mushroom anchors.** W. C. Johnson and S. E. Phillips. 6d.
9515. **Tanning by electricity.** E. Worms and J. Balé. 8d.
13,148. **Producing rectilinear or rotary motion by electricity.** F. Ross and A. Franzen. 6d.
13,447. **Electric railways and tramways.** A. L. Lineff and E. H. Bayley. 1s. 3d.

1888.

155. **Electrical turnstiles.** A. J. Boult. (Ehrling). 8d.
483. **Magnetic compass.** A. W. and F. S. Reynolds. 6d.

NEW COMPANIES REGISTERED.

Tunbridge Wells Electric Light Company, Limited.—Registered by Van Sandau and Co., 13, King-street, Cheapside, London, E.C. Capital, £300,000, divided into 6,000 shares of £5 each. Object: to carry on at Tunbridge Wells and elsewhere the business of an electric light company in all its branches, and, in particular, to construct, lay down, establish, fix, and carry out all necessary cables, wires, lines, accumulators, &c., and supply electricity to light the town of Tunbridge Wells and the neighbourhood thereof, and buildings and places, public or private, in the counties of Kent and Sussex. The first subscribers are:

	Shares.
H. E. Chetwynd-Stapylton, gentleman, 72, Warwick-square, London	10
W. H. Hodgkin, banker, Old Bank, Tunbridge Wells	1
G. Cheverton, chemist, South Lawn, Tunbridge Wells	1
E. Durrant, grocer, Pantilio, Tunbridge Wells	1
E. Waymouth, draper, 104, Calverly-road, Tunbridge Wells	1
Benjamin C. Coles, tailor, Tunbridge Wells	1
E. A. Hollingham, veterinary surgeon, Mount Zion, Tunbridge Wells	1

Until otherwise determined by the company in general meeting, the number of directors shall not be less than three nor more than seven. The first directors shall be appointed by the subscribers to the memorandum of association. The qualification of every director shall be the holding of not less than £50 in the stock of the company. The directors shall be paid out the funds of the company, by way of remuneration for their services, the sum of £50 per annum, and such further sum as the company in general meeting may from time to time determine, and such sum shall be divided amongst the directors as they may think fit.

Kensington and Knightsbridge Electric Lighting Company, Limited.—Registered by Deacon, Gibson, and Medcalf, 4, St. Mary-axe, E.C., with a capital of £250,000, divided into 50,000 shares of £5 each. Object: to purchase or otherwise acquire all or any part of the shares, works, undertakings, business, property and liabilities in and of the Kensington Court Electric Lighting Company, Limited, and for such purpose to adopt and perform, with or without modification or alterations, an agreement dated March 23, 1888, and made between Granville Richard Ryder, on behalf of the shareholders of the Kensington Court Electric Lighting Company, Limited, of the one part, and Douglas Eyre, on behalf of this company, of the other part, or such other agreement in lieu thereof as shall, in the judgement of the directors of the company, be expedient, with the object of acquiring the undertakings of the said Kensington Court Electric Lighting Company, Limited, and to make other similar agreements in addition thereto; to generate, produce, store, accumulate, and distribute electricity, electromotive force, or other similar agency for the purpose of lighting streets, public places, public or private buildings, manufactories, mines, ships, lighthouses, railways, tramways, and other places or things, and for the purpose of supplying motive power or heating in all or any of the before-mentioned places or things, or for plating, combining, separating, or otherwise working in metals, or for carrying out or facilitating mechanical operations, or for any other purpose whatsoever which may be now known or hereafter discovered, and to form, establish, and maintain centres for such purposes, or any of them. The first subscribers are:—

	Shares.
E. W. Cox, 11, Grayton-crescent, Hampstead, N.W.	1
W. Eacott, 9, Grove-road, South Hackney	1
S. Jordan, 36, Gertrude-street, Fulham-road	1
H. Gibson, 4, St. Mary-axe, E.C.	1
E. W. Lloyd, Heswell, Lancaster-road, West Norwood	1
G. Hamlin, 43, Somerleyton-road, S.W.	1
B. W. B. Ulph, 1, Findon-road, Uxbridge-road, W.	1

The number of directors shall not be less than three nor more than nine, and the following persons shall be the first directors, that is to say, Granville Richard Ryder, Alfred Solner Bolton, Sir Charles Grant, K.C.S.I., and Roger William. The qualification of a director other than the first directors shall be the holding of shares of the company of the nominal value of £100 at least; any director may act before acquiring his qualification. The remuneration of directors shall be determined in general meeting.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	$4\frac{1}{4}$
15 Feb.	10/0	Anglo-American	100	39
15 Feb.	20/0	— Pref.	100	$65\frac{1}{2}$
12 Feb., 85...	5/0	— Def......................	100	$14\frac{3}{8}$
29 Dec.........	3/0	Brazilian Submarine.........	10	$12\frac{5}{16}$
16 Nov.	1/0	Con Telephone & Main ...	1	11-16
15 Feb.	8/0	Cuba	10	$12\frac{3}{4}$
28 July	10/0	— 10% Pref.	10	19
14 Oct.	1/0	Direct Spanish	9	$3\frac{3}{4}$
18 Oct.	5/0	— 10% Pref.	10	$9\frac{1}{2}$
14 Oct.	2/0	Direct United States	20	$8\frac{7}{8}$
12 Jan.	2/6	Eastern	10	$11\frac{7}{8}$
12 Jan.	3/0	— 6% Pref.	10	$15\frac{3}{8}$
1 Feb.	5%	— 5%, 1899	100	$105\frac{1}{2}$
28 Oct.	4%	— 4% Deb. Stock	100	108
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	$12\frac{7}{8}$
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	$104\frac{1}{2}$
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	$104\frac{1}{2}$
12 Jan.	5/9	German Union	10	$9\frac{1}{4}$
27 Jan.	1/6	Globe Telegraph Trust......	10	5 1-16
27 Jan.	3/0	— 6% Pref.	10	14
3 Jan.	5/0	Great Northern..............	10	$14\frac{3}{4}$

Dividend.		Name.	Paid.	Price. Wednesday
1 Sept	5%	Gt. Northern 5% Deb., '83.	100	105x
28 July	10/0	India Rubber, G. P. & Tel.	10	$17\frac{1}{2}$
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5 5-16
16 March ...	5%	Maxim Weston	1	$\frac{1}{8}$
15 May	5%	Oriental Telephone	11	$\frac{1}{2}$
14 Oct.	4/0	Reuter's	8	$8\frac{1}{4}$
......	...	Swan United	$3\frac{1}{2}$	$2\frac{1}{4}$
15 Feb.	$15\frac{1}{2}$%	Submarine	100	142
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	40
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	15
......	...	West African	10	5
1 March ...	5%	— 5% Debs.	100	92
29 Dec.........	6/0	West Coast of America ...	10	$5\frac{5}{8}$
31 Dec.	8%	— 8% Debs.	100	116
14 Oct.	3/9	Western and Brazilian......	15	$10\frac{1}{8}$
14 Oct.	3/9	— Preferred	$7\frac{1}{2}$	$6\frac{5}{8}$
......	...	— Deferred..................	$7\frac{1}{2}$	$3\frac{1}{4}$
1 Feb.	6%	— 6% A	100	110
1 Feb.	6%	— 6% B	100	105
......	...	West India and Panama ...	10	13-16
30 Nov.	...	— 6% 1st Pref.	10	$10\frac{5}{8}$
13 May, '80...	...	— 6% 2nd Pref.	10	$6\frac{1}{2}$
2 Nov.	7%	West Union of U.S..........	$1,000	125
1 Sept.	6%	— 6% Sterling	100	101x

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Mar. ...	£39,670	+ £1,493
Brazilian Submarine	W. March 30...	£4,315	...	Great Northern	M. of Mar. ...	22,000	...
Cuba Submarine	M. of Mar. ...	3,800	+ £73	Submarine	None	Published.	
Direct Spanish......................	M. of Feb. ...	1,900	+ 37	West Coast of America	M. of Mar. ...	4,175	...
— United States	None	Published.	...	Western and Brazilian	W. March 30...	3,491	...
Eastern..............................	M. of Mar. ...	54,376	+ 4,579	West India and Panama	F. March 31 ...	3,703	+ 273

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Schanschieff Company.—The final batch of letters of allotment and regret in the Schanschieff Electric Light and Power Company were posted on the 5th inst.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended April 6, amounted to £4,503.

Eastern Telegraph Co.—The Eastern Telegraph Company's traffic receipts for the month of March, 1888, amounted to £54,376, and to £49,797 in the corresponding period of 1887.

Notice of Removal.—We are informed that Messrs. W. F. Dennis and Co. have removed from 101, Leadenhall-street, to 11, Billiter-street, London, where all communications relating to their business should be addressed.

Great Northern Telegraph Co.—The receipts of the Great Northern Telegraph Company for March were £22,000, making a total from January 1 to March 31 of £63,800 against £61,200 and £58,680 for the corresponding months of 1887 and 1886 respectively.

Eastern Extension, Australasia, and China Telegraph Company.—The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company for the month of March, 1888, amounted to £39,670, and to £38,177 in the corresponding period of 1887, an increase of £1,493.

Simplex Company.—At an extraordinary general meeting of this company on April 6th, it was decided that the company be wound up voluntarily, pursuant to the provisions of the Companies Acts, 1862 to 1886. Mr. A. H. Pownall, 69, Princess-street, Manchester, was appointed liquidator.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during March was 4,919, estimated to produce £3,800, against 4,775 messages, producing £3,727, in the corresponding month of last year. The traffic receipts for December, estimated at £3,300, realised £3,373.

Western and Brazilian Telegraph Company.—At a meeting of the board of directors of the Western and Brazilian Telegraph Company, Limited, it was decided, after placing £15,000 to renewal fund, and £10,000 to debenture redemption fund, to recommend a dividend of 9s. per share, free of income-tax, making, with the interim distribution, $4\frac{1}{4}$ per cent. for the year, against $3\frac{1}{2}$ for 1886. The receipts of this company for the week ending April 6, after deducting the "fifth" payable to the London Platino-Brazilian Company, were £3,554.

Indo-European Company.—The board of directors of the Indo-European Telegraph Company, after adding £10,000 to the reserve fund, determined, subject to audit, to recommend the payment of a dividend for the six months ended December 31, 1887, of 17s. 6d. per share, making, with the interim dividend already paid, per cent. for the year, and a bonus of 20s. per share, both free of income tax, making in all 10 per cent. for the year, carrying over £2,694 15s. 1d. The dividend and bonus will be payable on and after May 1 next. The Indo-European lines being now restored, the company is prepared to accept messages for transmission between this country and India, Penang, Singapore, China, Java, Australia, New Zealand, Persia, and Turkey.

The Oriental Telephone Company.—The report of the directors of the Oriental Telephone Company (Limited), for the year ended 31st December last, states that the revenue for the year exhibits a balance to credit of £5,854, which has been transferred to the profit and loss account. To this amount has to be added the sum of £4,769 brought forward, making a total of £10,624. In accordance with previous balance-sheets, the Indian guarantees for the year, viz., £2,406, have been debited to this account. The directors have deemed it advisable to reduce the item of preliminary expenses, and have consequently written off a sum of £1,128 in respect of these. They have further written off £259 for depreciation of stores at the various branches, the £121 in final settlement of losses on shipments of instruments to Australia on joint account, dating from 1882, with the Consolidated Telephone Construction and Maintenance Company, Limited. The net balance, therefore, to credit of profit and loss, after deducting the above items, is £6,708. The directors recommend a dividend for the past year of $2\frac{1}{2}$ per cent., free of income-tax, on the paid-up capital of the company other than the vendors' shares. This will absorb £3,106, and leave £3,602 to be carried forward. The report adds, the Telephone Company of Egypt continues to make satisfactory progress, and the dividend of 6 per cent. declared by that company for the past year on its preferred capital has been brought into the present accounts.

NOTES.

Barmen.—The number of installations is here 28, comprising 226 arc and 2,251 incandescence lamps.

Crefeld.—There are in this town 44 private installations, comprising 175 arc and 3,209 incandescence lamps.

Dresden.—There are here 30 installations of electric lighting, comprising 157 arc and 2,379 incandescence lamps.

Taunton.—The motion for the extension of the electric light in the streets at the last meeting of the Town Council was defeated by a small majority.

Berlin.—This city, which possesses the greatest number of central and particular lighting stations, contains 1,650 arc and nearly 26,000 incandescence lamps.

Breslau.—The Municipal Council is taking steps for the construction of a central station. The number of particular installations is 27, with 123 arc and 1,933 incandescence lamps.

Cologne.—The construction of several central stations is here under consideration. There are already 33 installations of electric lighting, comprising 101 arc and 2,727 incandescence lamps.

Baden-Baden.—The first electrical project at this place is to be the lighting of a new sanatorium by 300 incandescent and seven arc lamps. The work will be carried out by Th. Wechsler and Co.

Society of Arts.—A paper is announced to be read on Wednesday, May 6th, by R. E. B. Crompton, on "The Electric Lighting from Central Stations," when the Attorney-General (Sir R. E. Webster, M.P.) will preside.

H.M.S. "Victoria."—This vessel, built by Messrs. Armstrong, Mitchell and Co., has come round to Chatham for completion. The vessel is lighted throughout by electricity, and the guns are fired by the same means.

Society of Telegraph-Engineers.—The paper to be read at the meeting of the society on Thursday next, April 25th, is by Mr. W. H. Preece, F.R.S., past president, "On the Risks of Fire Incidental to Electric Lighting.'

Electric Lighting Act.—It will be seen from the report in another column, for which we are indebted to the *Times*, that the Electric Lighting Act, 1882, Amendment (No. 2) Bill was read a second time, in the House of Lords, on Tuesday.

Varzin.—Prince Bismarck's paper-mill at Varzin, which was burnt last year, has been rebuilt at a cost of £50,000, and it is now one of the largest and most complete establishments of the kind in Germany. It is lighted throughout by electricity.

Festival Lighting.— The electric lighting of the Palais de l'Industrie on the occasion of the *carrousel* on the 17th instant, was entrusted to M. H. Fontaine, who is president of the syndicate for the lighting of the Universal Exhibition of 1889.

Transformers.—The installation for the electric lighting of the town of Temesvar, in Hungary, is to be modified by the introduction of alternating machines and transformers. The latter are to be supplied by Messrs. Kremenezky, Mayer and Co., of Vienna.

Accumulator Patents.—The action taken by Messrs. Philippart Bros. against manufacturers of secondary batteries in Paris, which was referred to in a note in these columns last week, had been, according to the *Bulletin de l'Electricité*, threatened for some time past.

Hastings.—At the last meeting of the Council, a long discussion took place upon the report of the Lighting Committee, which had referred to it last December questions relating to the obtaining of independent tests as to the illuminating power of the electric light. The committee reported in favour of no steps being taken at present.

The 1889 Universal Exhibition.—The International Syndicate for the electric lighting of the Exhibition have elected as director M. de Boret, mining engineer; as chief engineer, M. Picou, manager of the works of the Continental Edison Co.; and as inspectors, MM. Napoli and Dumont, engineers of the Compagnie des chemins de fer de l'Est.

Tenders Required.—As will be seen from our advertising columns, the House-to-House Electric Light Supply Company, Limited, invite tenders for the supply of steam engines, boilers, and electric machinery. The specifications will be open for inspection at the offices of the Company on and after the 23rd inst.; but means have been taken to prevent its perusal from mere idle curiosity.

Munich.—Although no central lighting station has hitherto been constructed in this town, it includes forty-three establishments lighted by electricity, representing a total of 167 arc and 7,936 incandescence lamps. Besides these there are 2,300 incandescence lamps in the Imperial Theatre, 800 at the Ministry of War, a considerable number in the Chambers, and others in the markets on the quays.

Trouve's Auxanoscope.—This apparatus, which will probably be most useful for lecturers to popular audiences, is an electrical magic-lantern, which produces an image upon a screen by reflected or by transmitted light, or by both combined. It possesses the advantage of not requiring a very powerful luminous source; an incandescence lamp that can be worked by a few bichromate cells suffices to give a satisfactory result.

Cheap Curative Electricity.—One of the telegraph lines on the Wabash road, known as number four, has been a source of mystery to the operators for some time. It had spasms of going and stopping, and "old climbers" has been unable to locate the trouble until quite recently. He finally chased it down to where an old man had led a wire into his house near Wabash, Ind., and was applying electricity for the cure of rheumatism.

Incandescence Lamps.—It is stated that the new apparatus supplied by Messrs. Fritsche and Pischon, of Berlin, to the company in that city manufacturing the Seel lamps, considerably reduces the period necessary for the production of a vacuum by the Sprengel pumps hitherto used. The company is about to enlarge its works in consequence of the favourable reception of the Seel lamp in Germany. The lamp is stated to be very economical in working.

From America.—We have received from our contemporary, *Modern Light and Heat*, a neat little pocket-book filled with squared paper, suitable for graphic diagrams or notes. In addition to the paper, there is a printed slip containing some twenty-eight definitions, formulæ, and things to be remembered connected with electrical engineer-

ing. The whole is "with the compliments" of the paper. Duplicate books to fit the covers are promised by our go-ahead contemporary.

The Pervasiveness of Lightning.—A correspondent of the Springfield *Republican*, describing the effects of a recent lightning stroke, says that "the ceiling of the room had been replastered the preceding spring, and the sand of this locality, which is used in mortar, is ferruginous. Every metallic particle in the latter the fluid seemed to have found and detached, so as to give the plastered surface an appearance better described as pock-marked than by any other words at my command."

Leamington.—At a recent meeting of the Leamington Town Council, an account for £96. 5s. from the Electric Lighting Co., being the quarterly charge for supplying the electric light to the Parade, was passed for payment by the Finance Committee. It was stated that the sum now paid for the electric light is about double what was paid for gas for the same quarter of the town; but that there were twice the number of lights. Presumably, there would be much more than twice the quantity of light.

Dublin.—The Dublin Corporation announce that they have applied to the Board of Trade for a licence to supply electricity for all public purposes within that city. The applicants do not propose to take powers to break up any streets not repairable by the local authority, nor any railway; but they propose to be empowered by the licence to break up the tramways belonging to the Dublin and Lucan Steam Tramways Company, and those belonging to the Dublin United Tramways Company. They also propose to cross the River Liffey.

Lady Telephonists.—The following is from the *New York Electrical Review:* "New York City, we venture to say, has the best-natured and most tactful staff of telephone operators in the world. During the great storm, with all its exasperations and unlooked-for annoyances, the young lady operators were always accommodating, endeavouring in every way to aid the subscriber in securing answers to his calls. Manager Lockwood and his gentle-voiced staff may well be proud of their excellent work during and following the blizzard."

Water-Level Indicator for Steam Boilers.—At the last meeting of the Franklin Institute, Philadelphia, Pa., Mr. Morris P. Janney described a new electrical water-level indicator for steam boilers, by Charles Wickersham, of Pottstown. It is a device which will constantly indicate by means of a dial and index the height of water, and shows its rise and fall in inches and fractions. Attached to it is an electric annunciator, with visible and audible signals, for indicating at any distant point the variation of water level in the boiler beyond the prescribed limits.

Church Lighting.—The parish church of Blockley, a large village on the southern border of Worcestershire, is shortly to be lighted by electricity. The installation is being carried out by a company, who have taken some old mills near at hand for manufacturing purposes, and the machinery will be driven by water-power, of which there is an abundance available. This is by no means the first church that has been illumined by electricity; and we were recently informed that, in China, the Governor of Tamsni has had his Yâmen lighted by the same agency.

Lecture Lantern.—An improved form of lantern for the projection of photographic and other slides on to a screen, has recently been supplied by Messrs. Drake and Gorham to the Royal Society, to which institution this firm act as electrical engineers. This lamp, in addition to the condenser and ordinary lenses, has been fitted with a special prism arrangement for projecting horizontal surfaces on the screen. The lantern is fitted with a Brockie-Pell arc lamp, which burnt remarkably steadily at the recent Bakerian lecture given by Mr. Norman Lockyer, when the plant was run for the first time.

Hamburg.—There are in this town 70 establishments lighted by electricity, comprising about 300 arc and 4,500 incandescence lamps, besides two central stations, and one in course of construction, each supplying 1,000 lamps. Since 1882 the Municipal Council has had a central station for lighting the Senate House with the adjacent buildings, the square of the Hotel de Ville, and three warehouses. The Council now propose to establish a central station supplying 10,000 lamps, and capable of working double this number. In the warehouses of the Free Port there are, moreover, 50 arc and 4,000 incandescence lamps, and several electric lighting projects are under consideration.

Breslau.—A committee, says *Industries*, appointed by the Town Council to inquire into the best means of installing the electric light in the town, has reported in favour of a large central station to supply 5,000 lamps, distributed throughout an area the boundary of which is at no point farther than 1,200 metres from the generating station. It is not intended to ask public tenders for this installation, but to entrust it to Messrs. Siemens and Halske, of Berlin, who will submit an estimate based upon a general plan of the district. The management of the central station will be in the hands of the Municipality. These recommendations of the committee have not yet been finally adopted.

Paris-Lyon-Marseilles Telephonic Line. — The Prefect of the Department of the Rhone has communicated to the Lyon Chamber of Commerce a letter, in which the Director-General of Posts and Telegraphs announces that the work in connection with this line will probably be completed within two and a half months. It is probable that communication will be established between Lyon and Marseilles about the middle of next month, and between Lyon and Paris about the middle of June. In regard to the proposed line between Lyon and St. Etienne, the offer of the Lyon Chamber of Commerce to advance the sum necessary for its establishment, with a view to obviate any delay in commencing the work, will no doubt be accepted.

Legal.—The great lamp case between the Edison-Swan Company and Mr. Holland, or rather between the former and the Brush Company, has been proceeding during Tuesday, Wednesday, and Thursday of this week, and will be continued on Monday next. The opening for the plaintiffs and the evidence in their favour is very similar to what has been put forward in previous cases, and we think has no very great interest for our readers generally. It is said that the defendants have some new evidence to bring forward, and this will probably form the most important feature of the case, except the judgment. Of course, the greatest interest will centre in the latter. For the present it is absolutely impossible to foretell what this will be, and patience must be exercised for some days to come.

Electric Lighting in Germany.—At a recent meeting of the German Association of Gas and Water Engineers, a report on the position of electric lighting in

Germany was read by Dr. Shilling, who pointed out that, although the new illuminant has been most largely adopted outside of the circles of distribution supplied by the gas companies, it must be admitted that it had also made notable progress in several cities supplied with gas. Taking an aggregate of thirty large towns, the number of establishments lighted by electricity had augmented in the course of the two last years from 138 to 604; the number of arc lamps from 591 to 3,280, and that of incandescent lamps from 10,403 to 50,469—amounting to about 4 per cent of the number of gas-burners in the same towns. The present position of electric lighting in some of the largest of these towns will be noted under their respective names.

Weston-super-Mare.—Agitation is still going on to obtain the electric light. At the last meeting of the town authorities a letter was read from Dr. Wicksteed, as follows:—"May I ask of you, in the name of a very large and influential body of ratepayers (whose interests I have frequently represented at your monthly meetings), what steps your Board propose taking as regards the adoption of the electric light for public and private purposes in the town? The season will soon commence. The public want the light. Pray enlighten them. The illness of my son takes me away from home for the next three weeks, therefore I should be glad if your answer to this note could be a public one." Mr. Knight said the Board had thought the matter over, and they had been waiting until the new Board had been elected. After this had been done it would be well to appoint a committee to discuss the subject; in fact, there was a resolution down to that effect.

Contact Electricity.—Exner's recent researches in support of his contention that there is no such thing as contact-electrification were founded on his experimental results, that if an insulated conductor be connected with an electrometer, and the latter then disconnected from the earth, and if the capacity of the conductor be then altered, the electrometer will remain unaffected; whereas, according to the contact theory, there should be a flow of electricity. The conclusion of Exner has been objected to by Hallwachs, but Exner is still inclined to support his own opinions, and states that the objections raised against them do not carry any weight. He claims that no change is produced when the grating is brought into contact with a conductor consisting of a different metal; such a change is required by the contact theory. He has not attempted to determine whether it would be required by the chemical theory, nor, so far as he is aware, has the question been considered by others.

The Electric Light in Italy.—The central station at Terni, which was completed in February last, is capable of supplying 3,000 incandescence lamps of 16 c.p. The works comprise three groups of machines, each composed of a Girard turbine of 150 h.p., an alternating-current dynamo of 2,000 volts and 40 amperes, and the means for exciting the latter. The works are established outside the town, at 200 metres from the walls. The current is distributed by means of 21 Zipernowski transformers, each of 7,500 watts; the tension of the secondary current being 100 volts. All the conducting wires are uncovered and overhead. Besides the lighting of private houses, the station supplies the public lighting of the town, maintaining 350 incandescence lamps, of which the candle-power varies from 10 to 50, and which are charged for at the rate of 4 to 13 centimes (·4 to 1·3d.) per hour. Electric lighting has been recently introduced in the towns of Arellino and Omegna. The Arellino station, which is by far the more important, is capable of maintaining 2,500 incandescence lamps.

Properties of Molten Silver.—At a recent meeting of the Société Française de Physique, M. Violle made known the results of his researches on this subject. He in the first place examined into the emission polarisation which was pointed out by Arago, but which has recently received but little attention, probably by reason of the difficulty of a clear incandescent surface. The photo-polarimeter of M. Cornu exhibited a polarisation increasing regularly from 0 to 80 degrees. The proportion p of polarised light contained in the beam from the molten metal is 0·17 under an angle of 30°, 0·33 under an angle of 45°, 0·55 under an angle of 60°, 0·77 under an angle of 75°, and 0·84 under an angle of 85°. The results of observation are expressed by the following formula:—

$$p = (1 - \cos i)\left(1 + \cos 75 + \frac{i}{5}\right).$$

In the second place M. Violle sought to compare the total energies respectively radiated by silver and by platinum at their temperatures of fusion. By means of a thermo-battery he found that the total radiation from melting platinum is 54 times that from melting silver. The ratio of the luminous intensities is 20 times greater.

Illumination.—We translate the following from the *Formulaire* of M. Hospitalier:—The illumination produced at a given point by a luminous focus is the quotient of the illuminating power of this focus by the square of the distance from it of the point in question. The practical unit of illumination is the *candle-metre* or *carcel-metre*, *i.e.*, the illumination produced by a standard candle or a carcel burner placed at the distance of a metre. From 20 to 30 candle-metres of illumination are required at any point to constitute a sufficient light, and at least 30 candle-metres are required on a reading table to avoid fatiguing the eye. The illumination produced by a source of light is proportionate to the intensity of this source and inversely proportionate to the square of its distance from the point to be illuminated. Consequently, illumination should be expressed, not in candle-metres or carcel-metres, but in *candles per square metre*, or in *carcels per square metre*. The light radiated by a candle through a sphere of 1 metre radius is distributed over a total surface of $4\pi r^2 = 12{\cdot}6\ m^2$; the illumination is therefore 12·6 times less than if the whole of the light produced by the candle illuminated a surface of $1 m^2$ at a distance of 1 metre. The candle per square metre is consequently a unit 12·6 times greater than the candle-metre. An illumination of 1 candle per square metre is requisite to enable one to write as easily as in daylight.

St. James' Vestry.—At the meeting of the Vestry on April 12, the Lighting Committee recommended that the consent of the Vestry be given to the St. James' and Pall Mall Company, but after a considerable discussion the matter was referred to a committee of the whole Vestry for further consideration. This was at the instigation of a Mr. Winnett, who wondered why electric lighting companies desired a particular part of the parish to light. Mr. Winnett's arguments against permission by the Vestry were of the usual stereotyped, pig-headed, John Bull type. Someone else had spent a lot of money, and failed: *ergo*, the present company must also fail. We know nothing of the companies referred to one way or the other; but we do know this, that no argument of such a kind is worth a

moment's consideration. We do not hold that a vestry should consent at the first request; but surely if the matter has been referred to a committee, and that committee has made due inquiries as to the plans of the company, and reported favourably, it seems absurd that another committee should have to go over the same ground and do the same work over again. The vote of the Vestry is simply this: we form a committee consisting of certain men to do certain work, because we thought them capable of doing that work satisfactorily; but now they have done the work, we say they were incompetent, and the work must be done over again. Is not this a fine example of Bumbledom?

Portable Electric Lighting Apparatus.—The apparatus constructed by Ganz and Co., of Buda-Pesth, to facilitate the movement of troops by railway transit during the night has been found very servicable during certain manœuvres in South-Eastern Hungary, on the frontier of Roumania. Its main purpose is to avoid confusion at railway stations on the occasions of the embarkation or arrival of large bodies of men. It comprises a transportable steam-engine of 8 h.p., in the rear of which is located an alternating-current dynamo machine of the Zipernowski pattern, capable of working eight arc lamps, each of 600 candles. A van, somewhat similar to those employed for the transport of furniture, carries, in addition to the lamps and their supports, the posts which are to carry the line, 2,000 metres of wire coiled on a drum (which is mounted upon a carriage), the necessary tools, and two water-tanks for the supply of the engine. Both the engine and the van are constructed to be readily transferred to railway-platform waggons, and thus transported by rail. On arrival at a given railway station, some of the workmen erect the posts and locate the lamps at the points indicated to them, whilst the engineer is getting up steam. Less than seven hours suffice for the installation, by eight workmen, a fitter, and an engineer; whilst the whole apparatus can be dismounted within five hours. The cost of the lighting for the eight arc lamps, during ten hours, was 17·5fr.; the whole apparatus costing about 21,000fr.

Photochronoscopic Method of M. Hermite.—To obtain a distinct photograph of an object moving with great velocity, as, for instance, a rifle bullet travelling at the rate of 400 metres (1,304ft.) per second, is *primâ facie*, and from the popular point of view, a somewhat difficult problem. It has been very neatly solved, however, by M. Gustave Hermite, under the condition that the object must be in darkness. He simply illuminates it by the spark from an induction coil. The sparks from this instrument occur at perfectly regular intervals of time, so that the only practical difficulty in carrying the suggested means into effect is to accurately measure the duration of the interval. This, M. Hermite has accomplished by the use of a diapason, of which the number of vibrations per second is accurately known, and which is simply a thin strip of steel fixed in a metallic holder. It is set in vibration by bending it with the finger. If now it be illuminated by sparks from a Ruhmkorff coil, and the number of vibrations of the strip happens to be equal to that of the sparks, the strip will be seen in a position of inclination. If the number of sparks be double that of the vibrations, the strip will be seen in the form of a V. If there be discord between the numbers, the branches of the V will appear to close and then to open again. It will be seen that these phenomena afford a means of regulating the coil so that it may give a determinate number of vibrations and sparks per second; and the means in question are found to be very practical and very accurate.

Incandescence Filaments.—Some interesting observations relative to the carbon filaments of incandescence lamps have recently been made. In testing chemically certain filaments said to be of a material other than carbon, Mr. Desmond Fitz-Gerald boiled them in strong sulphuric acid, with the view, if carbon were present, of obtaining carbonic oxide and sulphurous acid according to the reaction

$$H_2SO_4 + C = CO + H_2SO_3.$$

No such reaction occurred; the filaments in question remaining unaltered. Before committing himself, however, to the conclusion that no carbon was present, the experimenter took the precaution of repeating the experiment with filaments known to be of carbon. These filaments also remained unaltered after prolonged boiling in the acid. This result justifies the conclusion that the carbon of lamp filaments, unlike ordinary carbon, is not acted upon by sulphuric acid at its boiling point. It confirms also the conclusion arrived at by Mr. Anthony, that the molecular constitution of a filament of carbon, obtained by heating to redness a filament of organic matter, becomes modified when the material is subjected for a certain period of time to the comparatively high temperatures obtained by its incandescence as a lamp-filament. Mr. Anthony found that this molecular change is indicated by an increase in the specific resistance of the carbon. Operating with a new filament, he observed that a diminution in its resistance occurred at a comparatively low temperature, and that the resistance steadily diminished as the temperature was augmented. But after the filament had been allowed to cool, its initial resistance was found to have augmented. The same fact has been observed by other investigators; but one of Mr. Anthony's results is probably altogether novel. Operating with certain incandescence lamps taking currents of 6, 8 and 10 amperes, and giving luminous intensities of 32, 65 and 125 candles, he found that the resistances of the filaments had appreciably diminished after the lamps had been working for from 200 to 300 hours, and that subsequently the resistance steadily increased up to a certain point as the working was continued.

Bath.—At the meeting of the Bath Town Council, the most important item on the agenda was: "To receive a report from the committee appointed on the 2nd of August last to consider the question of lighting the streets of this city with the electric light." The report simply stated that the committee had made enquiries of other towns where the light had been adopted, and awaited further instructions. The Town Clerk said before they proceeded, he would read a clause from the Municipal Corporations Act. It was as follows:—"A member of the Town Council shall not vote or take part in the discussion of any matter or matters in which he has, directly or indirectly, by himself or by his partner, any pecuniary interest." Mr. Comman said he could not accept that ruling. If shareholders in the gas company or electric lighting company could not vote, then half the Council were debarred, which was ridiculous. Alderman Chaffin, as one of the directors of the gas company, could not conceive anything more cruel or more unjust than that the mouths of those who happened to be shareholders, or interested in the gas company, should be closed, and that they could not point out, as ratepayers, the disadvantages of any new system

SAINT-ETIENNE CENTRAL LIGHTING STATION.*

BY HYPPOLYTE FONTAINE.

The works installed at Saint-Etienne for the electric lighting of the central portion of the town by the Edison system are shown in the accompanying illustrations. Figs. 1, 2, 3, and 4 relate to the machine-room, and Figs. 5, 6, 7, and 8 to the mode of grouping the dynamos and to the switch-board arrangements.

The Edison Electrical Company of Saint-Etienne was established in May, 1885. Its works, which were initially designed for the supply of 1,100 amperes, were inaugurated five months afterwards. By successive developments they have now been made capable of supplying 2,600 amperes.

The light is supplied at the price of 6 centimes (⅗d.) per lamp hour of 16 candles. The charge made is by meter, but each client pays an annual fixed sum of 3fr. 50 centimes (2s. 11d.) in addition to the price of the current supplied.

The works are situated in the very centre of the town, in a yard having an area of about 300 square metres (about 360 square yards). Owing to the limited space at disposal, a special arrangement has been adopted. The boilers are placed at the level of the soil, and the walls separating them serve as foundations for the engines. These walls, in which are contained the flues (*vide* Fig. 3), rise about 2m. (6½ft.) above the boilers. On the other hand, the protecting wall, constructed in accordance with the official regulations for the protection of the adjoining property, serves as a foundation for a portion of the dynamos.

On the level of the summit of the flue-walls is the flooring of the dynamo-room. The means of transmission are arranged within the space of 2 metres (2 yards 7in.), between the top of the boilers and the flooring of the machine-room.

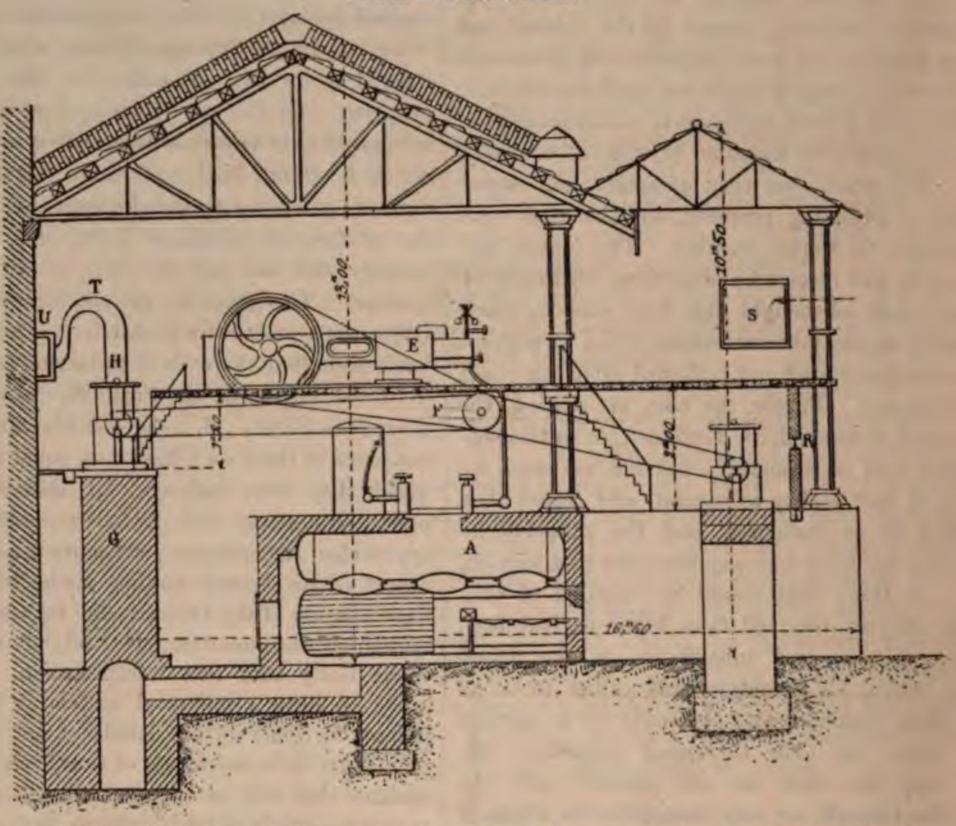
The means for generating steam consist of four boilers with interior fire-boxes on the Farcot system, having 90 square metres (about 1,100 square yards) of heating surface. The flue receiving the smoke is situated at the base of the protecting wall, and communicates with a shaft, 45 metres high, placed at the angle of the works. The boilers are supplied with water by means of two independent Kœrtling injectors and a supplementary donkey-engine. The escaping steam, even that which may pass from the safety-valves, is collected by a cast-iron pipe, and used to heat the feed-water. The system of steam-escape is so arranged that, by turning a valve, the steam may pass direct to the shaft or to the feed-water. The engines, like the boilers, are four in number. They are high-pressure compound tandem engines. The slide-valves are rotary, on the Coffinal system, with expansion gear regulated by hand. The cylinders are 280 (about 11in.) and 420 (about 16·5in.) millimetres in diameter, with the same stroke of 600 (2ft.) millimetres. The cranks make 160 revolutions per minute. The consumption is about 10 kilogrammes (22lb.) of steam per h.p.

At the pressure of 6 kilogrammes each engine normally develops from 70 to 75 h.p. effective. At the pressure of 11 kilogrammes, from 180 to 190 h.p. effective can be obtained.

The steam cylinders are, of course, steam jacketted.

The engines are each provided with two fly-wheels, one at each extremity of their crank-shafts. The fly-wheels on the distribution side are connected by means of belting to pullies on an intermediate shaft extending throughout the length of the machine-room, and thence by other belting to the dynamo pullies, the dividing belt passing beneath the flooring. In order to carry out this arragement, which has the advantage of not encumbering the engine-room with belting, the floor of the dynamo-room was lowered 1·20m. (nearly 4ft.) beneath the engine-room flooring, whilst, by means of wide supplementary staircases, access to the dynamos is facilitated.

Fig. 1.—Section on A B.



A Boilers. E Engines. F Intermediate Shafting. G Protecting Wall. H Edison Dynamos. T Cable from Dynamos to Collectors.

The engines can work independently or together, according to the requirements of the service. With this view the shafting is in sections, and can be connected as required by clutches.

Piat pulleys are used, 900m. in diameter (about 1yd.). All the pulleys have friction clutches, and can be thrown in or out of gear as required. In this manner the dependence or independence of each engine and of each dynamo is in great measure obtained at will.

The distribution is effected by three conductors at from 225 to 230 volts at the terminals.

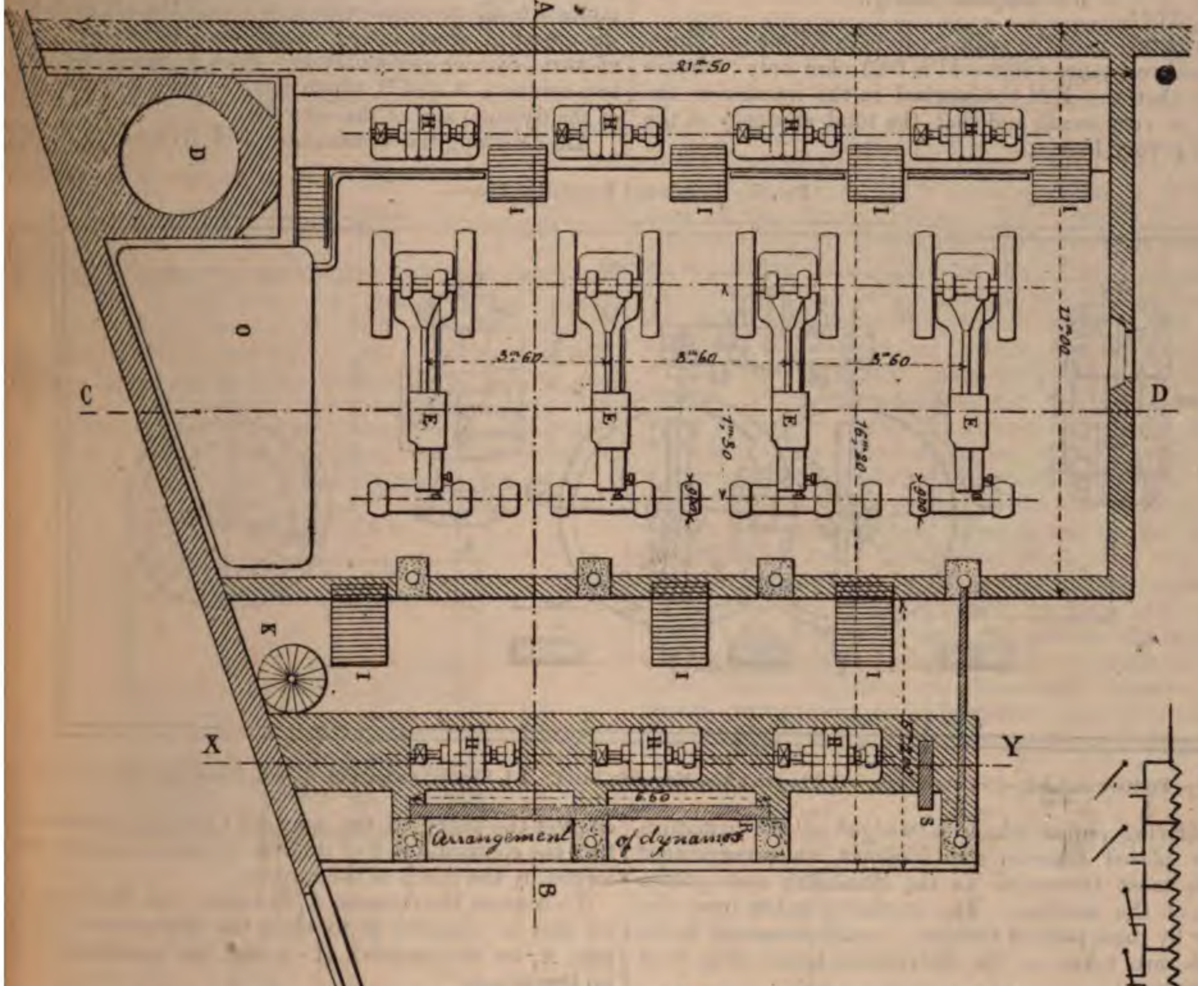
The dynamos are seven in number. The type initially

* Translated from the *Revue Industrielle*.

dopted, when the output was only 1,100 amperes, was that f 375 amperes and 120 volts; it was necessary to adhere

tity. The dynamos are mounted on rails and can be shifted by means of screws when it is necessary to tighten the

Fig. 2.—Plan of Installation.



A Farcot Boilers. B and C Flues. D Chimneys. E Engines. H Dynamos. I Stairs.

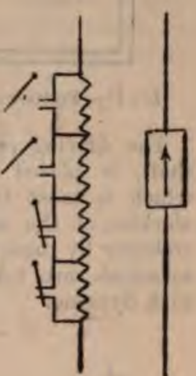


Fig. 7.

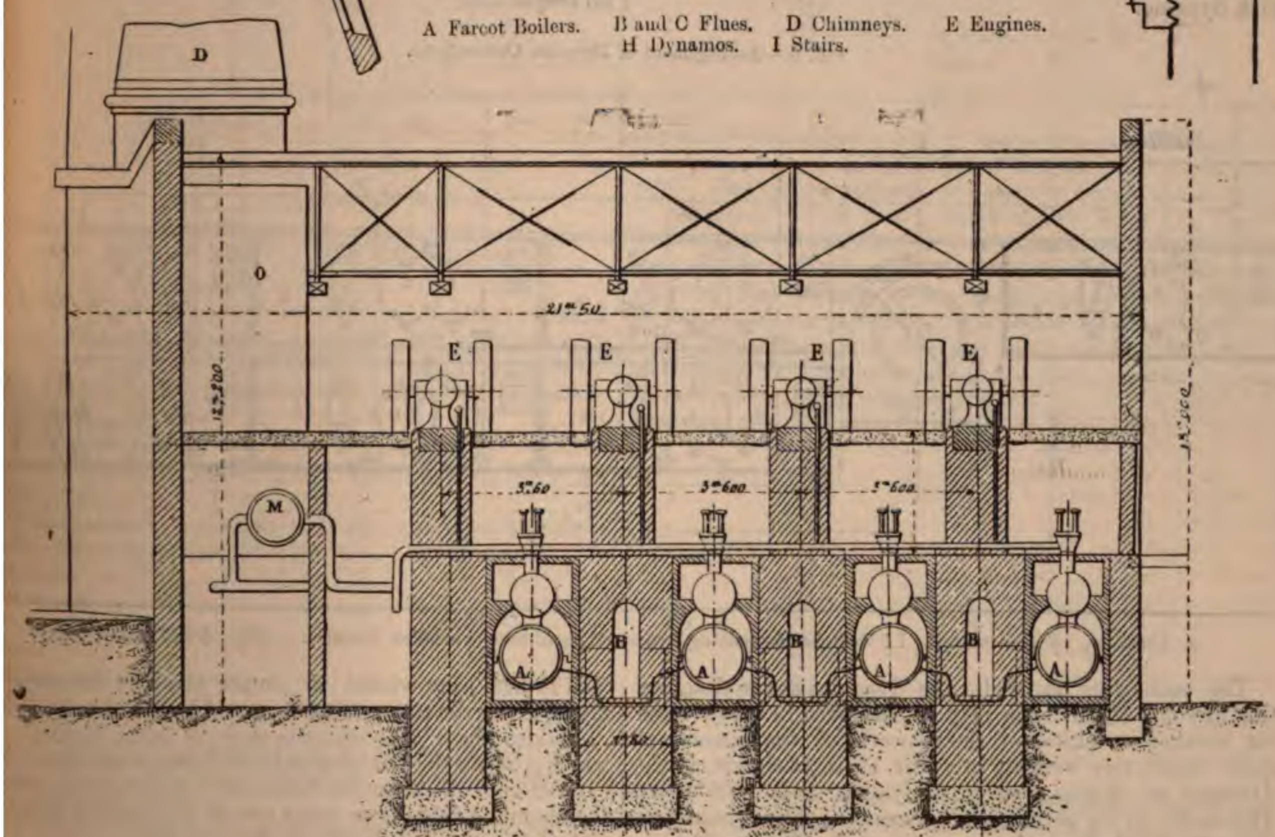


Fig. 3.—Section on C D.

it when the works were extended, in order to maintain iformity of yield, and to allow of easy grouping for quan-

belting. The magnetic field is generated by a group of three electromagnets, each having two arms, or altogether by six

coiled arms, connected in two series of three in multiple arc. The exciting current has an E.M.F. of 220 (? 240) volts. Each of these having a resistance of 45 ohms, the joint resistance of the whole is 33·75 ohms (? 30 ohms), and the current consumed is $\frac{220}{33{\cdot}75} = 6{\cdot}5$ amperes nearly.

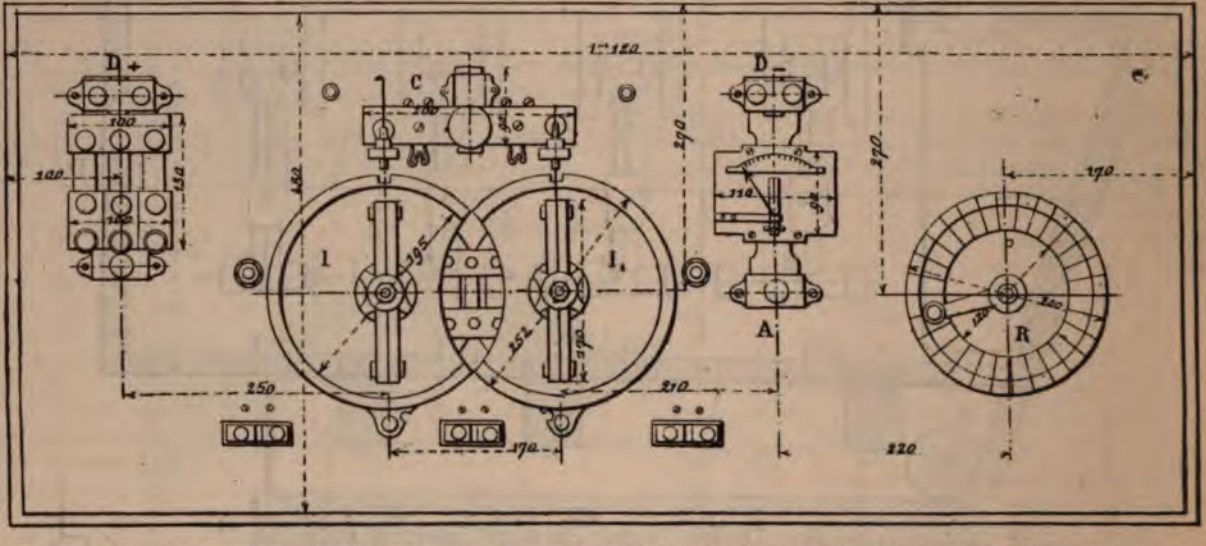
The armature is of the ordinary form in Edison machines. Its internal resistance when cold is 0·01 ohm only; whence it follows that the E.M.F. absorbed in the interior of the machine is very small, and that the total efficiency of the dynamos is very high.

The arrangement contrived by M. Ebel will be read understood by referring to the details of a switch-bo (Fig. 5) and to the sketch (Fig. 8).

The dynamos A and A_1 are connected in series by me of the circular commutators, 1, 2, and 1_1 2_1. These comn tators are all provided with notches in the arc of a cir the object of which is to prevent the simultaneous acti of two adjacent commutators. Each commutator carr two contacts, A and B, which serve to complete the circu of the dynamo and of the network.

After turning the commutator 1 of dynamo A, so as

FIG. 5.—Switch and Regulation Board.



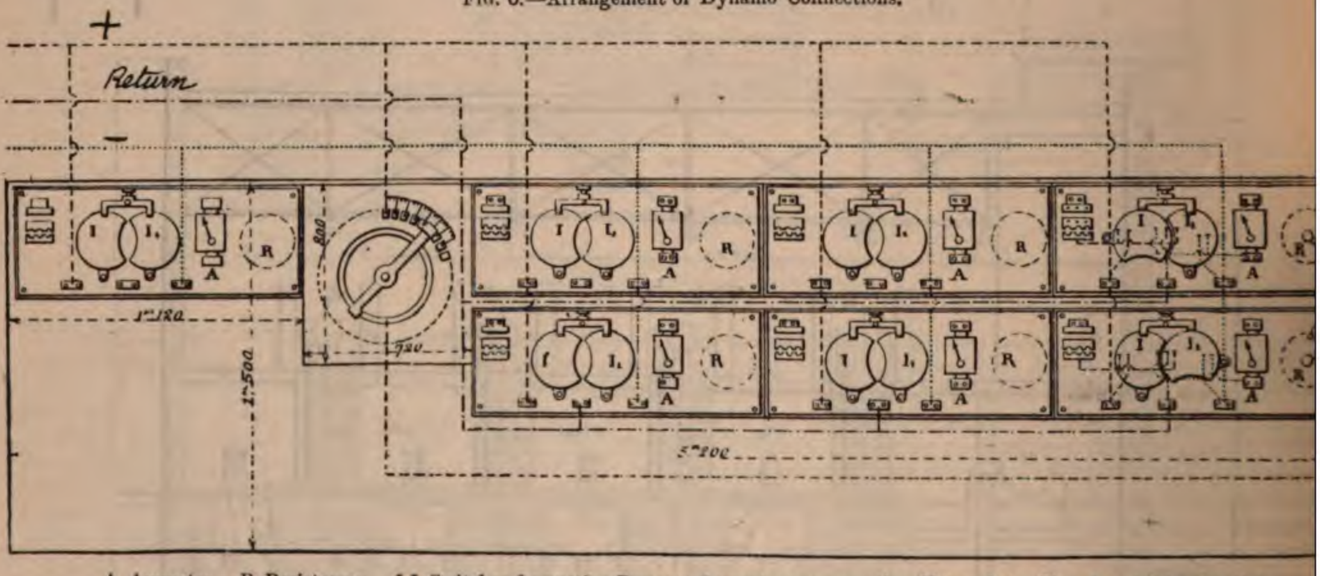
D+D− Positive and Negative Terminals. C Plug to Close Magnetic Field. I I Regulators (v. Fig. 8). R Resistance Magnetic Field.

The driving pulley, which is wedged on the armature shaft, is placed between two supports, an arrangement which is most favourable to the durability and proper working of the machine. The current is taken from the collector by three pairs of brushes. Leads connected to the terminals are taken to the distribution-board (Fig. 5) of each dynamo.

connect the latter to the network (+1) it is impossible turn the commutator 2 of the same dynamo, since it becon locked by the notch of the former.

To connect the dynamo A_1 in series with the dynamo all that is required is to close the commutator 2_1 whi puts A_1 on the network (I −), and the commutator 2 c no longer act.

FIG. 6.—Arrangement of Dynamo Connections.



A Ammeter. R Resistances. I I Switches for putting Dynamo Current on one or other Network (v. Figs. 5 and 8 for details).

The connecting boards for the dynamos are so designed that any one of the latter may be employed in substitution for another on either of the networks of the system of three conductors without any fear of short-circuiting the dynamos, or placing them in derivation under 200 volts. This is due to the gearing arrangements of the accumulators patented by M. Ebel, the manager of the Edison Electric Company, of Saint-Etienne. By this system an inversion of the intended arrangements is automatically rendered impossible, and the due preservation of the generators and utilisers of the electric current is assured.

If it had been wished to couple the two dynamos i multiple arc, the commutator I_1 would have had to be closed

Besides these contrivances, there is other locking gea which prevents the commutators from being closed prior to th excitation of the magnetic fields, and, conversely, to preven the magnetic fields from being cut off prior to the interrup tion of the external circuits of the dynamos.

At starting, the distribution had been established wit two conductors; the leads resting on glass cubes in brick of cement. But when the network was extended, th Edison system, with three conductors, was adopted.

he three conductors are round bars of copper, separated n each other by wood blocks soaked in paraffin, the le being enclosed in iron tubes filled with resin.

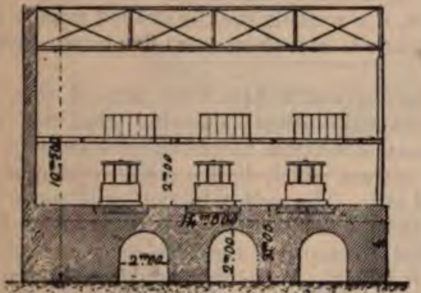
he copper bars project a few centimetres beyond the s of the tubes, and are connected by soldering to them ll copper cylinders. The ends are enclosed within es of cement, into which also melted resin is run.

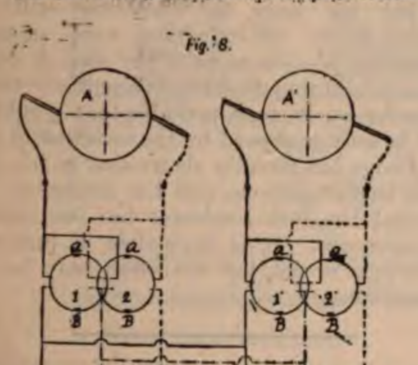
he four feeders have the following lengths and sections:

No.	Length in metres (39·37in.)	Section of positives and negatives (sq. mm.)	Section of intermediaries.
1	375	415	200
2	222	255	143
3	520	490	255
4	700	710	415

The network, properly speaking, to which the lamps are nnected, has a total extent of nearly 5,000m., about 40 yards. It has been constructed with conductors of o different sections, according to the current and E.M.F. quired. One of these types consists of a positive and gative of 200 square mm. (about ·3 square inches), with intermediate of 140 square mm. (about ·2 square inches); e other of a positive and negative of 140, and an interediate of 100 square mm. (about ·15 square inches).

Fig. 4.—Section on X Y.





he whole of the plant in fixtures, boilers, engines, amos, connection-boards, network, and branches cost roximately 500,000fr. (£20,000), for which sum about 0 lamps have been installed and motive power ributed.

he expenses of working bring the cost of the ampere- r to 0·0325fr. (about ·325d.) These may be taken as ows :—

our	0·009fr.
l at the average price of 13fr. per 1,000kg.	0·01
brication	0·001
intenance	0·0025
neral expenses, water, rent	0·01
Cost of the ampere-hour	0·0325fr.
(or about ·325d).	

hese figures are applicable to an annual production of ut 1,500,000 ampere-hours for an average number of 0 lamps installed.

he above information has been obligingly supplied by Chatard, the manager of the Continental Edison Comy at Paris. During a recent visit to Saint-Etienne, Gramme and M. Fontaine were able to verify their racy, and to satisfy themselves that the works are erly constructed with regard to safety and economy, M. Ebel, the manager of the station, explained in detail the working of the apparatus, and especially that of the switch-boards devised by him.

THE VARIATION OF THE CO-EFFICIENTS OF INDUCTION.*

BY W. E. SUMPNER, B.SC.

The co-efficient of self-induction of a coil whose magnetic circuit is wholly or partially composed of iron is such a variable quantity, that it is necessary to define its meaning more exactly than has hitherto been done. Of the many definitions possible to give, the best is probably that according to which it is the ratio of the induced electromotive force to the rate at which the current is changing; since the induced electromotive force is equal to the rate at which the magnetism is in changing, the ratio in question is the rate at which magnetism changes with the current. From this it follows, that if a curve be drawn whose abscissæ represent the current and whose ordinates represent the amount of magnetism or the number of lines of force enclosed by the coil, the co-efficient for any particular current will be represented by the rate of slope of this curve. The shape of these curves is well known from the researches of Prof. Ewing, Dr. Hopkinson, and others. They are generally such that, as the current increases, the curve slopes very gradually at first, but becomes steeper and steeper until the current begins to saturate the iron. The curve then bends over, and the slope becomes ultimately small. When the current is diminished, the curve of magnetism, owing to magnetic hysteresis, does not return on itself, but is such that it becomes steeper and steeper as the

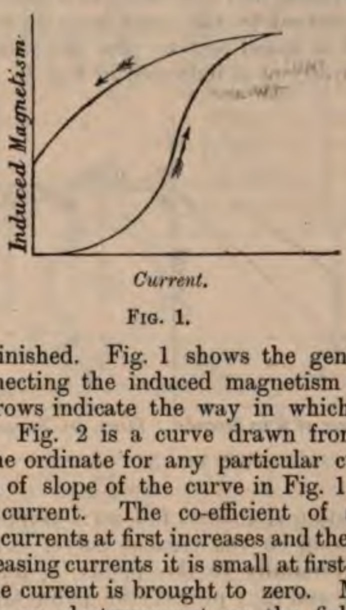


Fig. 1.

current is diminished. Fig. 1 shows the general shape of the curve connecting the induced magnetism with the current. The arrows indicate the way in which the current is changing. Fig. 2 is a curve drawn from Fig. 1, and is such that the ordinate for any particular current represents the rate of slope of the curve in Fig. 1 for the same value of the current. The co-efficient of self-induction for increasing currents at first increases and then diminishes, while for decreasing currents it is small at first, and steadily increases as the current is brought to zero. Many experiments made on an electromagnet, on the field-magnets of dynamos, and on a Kapp transformer have completely con-

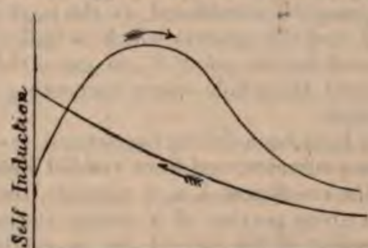


Fig. 2.

firmed these conclusions. Owing to magnetic hysteresis, the number of lines of force enclosed by the coil will depend not only upon the current flowing at the moment, but also on those that have been flowing previously. The value of the co-efficients will, for the same reason, depend

* Abstract of paper read before the Physical Society of London, April 14th, 1888.

on the former magnetising forces, and may be obtained of almost any value by using suitable magnetising currents before the determination is made.

The co-efficient for an increase of current will always be different from that for a decrease of current. These effects of hysteresis were obtained in all the experiments made, and were very marked in the case of a Kapp transformer. Several methods were used for determining the co-efficients. The chief were Maxwells' absolute method, and a modification of it by Professor Ayrton—a comparative method (due to the author) by which the co-efficient was found in terms of the capacity of a standard condenser, and the secohmmeter of Profs. Ayrton and Perry.

There is a simple graphical method for determining the current flowing at any moment when the electromotive force is given at each instant, and the co-efficient of self-induction is given for every value of the current. In the case of a simple circuit the following equation holds true—

$$\mathrm{E} - \mathrm{L}\frac{d\,\mathrm{C}}{d\,t} = \mathrm{R\,C}.$$

Where C is the current, E the electromotive force—which is not necessarily constant—L the co-efficient of self-induction, and t the time. It follows that

$$\frac{d\,\mathrm{C}}{d\,t} = \frac{\frac{\mathrm{E}}{\mathrm{R}} - \mathrm{C}}{\frac{\mathrm{L}}{\mathrm{R}}} = \frac{\mathrm{C}_0 - \mathrm{C}}{\frac{\mathrm{L}}{\mathrm{R}}}.$$

Now, E/R is what the current would be if there were no self-induction, and is given, we suppose, for every moment. Call it C_0, and plot a curve, having C_0 for ordinates and time for abscissæ. Plot another curve, having current for ordinates and the corresponding values of L/R as abscissæ. If L is given in secohms and R in ohms, L/R will be in seconds, and must be plotted to the same scale as for the former curve. It will be found best to plot the values of L/R in the negative direction, as indicated in Fig. 3.

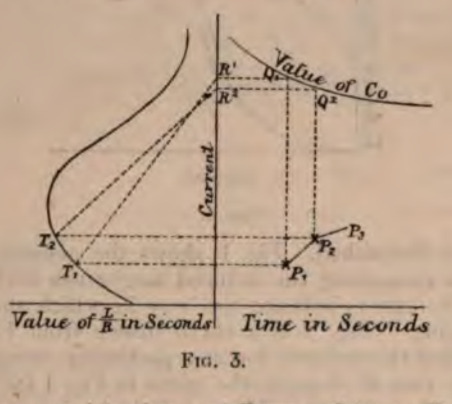


FIG. 3.

The construction is then as follows:—Suppose P_1 be the given initial point on the current curve. Project it horizontally and vertically to the points T_1 and Q_1 on the curves for L/R and C_0; project the point Q_1 horizontally to R_1 on the current line. Draw from P_1 a line parallel to the line $\mathrm{T}_1\,\mathrm{R}_1$, and choose a point, P_2, on it not far from P_1. The point P_2 may be considered as the next point on the current curve, and the process which is indicated in Fig. 3 may be repeated for the point P_2 to get a third point, P_3, and so on until the whole curve connecting current and time is obtained.

The curves have been drawn for several cases of steady and alternating currents, and have yielded some interesting results. If the co-efficient L is a variable, the time taken to establish a given portion of a steady current will vary with the amount of the current to be established. The current may increase at very different rates during the rise, and may hasten and slow and hasten again while increasing, in a very remarkable manner. Prof. Thompson has observed some of these effects experimentally.

The general effect of the variation of L is to introduce ripples into the curve of current obtained by assuming that L is a constant and equal to the mean of the different values. It is generally assumed in calculations connected with alternating currents that the E.M.F. of the dynamo is a sine function of the time, and that the co-efficient L is a constant quantity. Although these as tions are well known to be inaccurate, they are ger believed to be sufficiently true for practical pu It is very doubtful whether this is the case. Experi made on the Ferranti dynamo at the Central Insti have shown that the electromotive force curve is such t ordinates differ from those of the most favourably sine curve by as much as +5 per cent. With other dy probably much greater variations occur. Probabl with some dynamos the curve of electromotive force i like that which would result from the sum of two sine one with a period corresponding with the current nations, and the other with a period coinciding that of the dynamo revolutions. This will occur ever there is want of symmetry in the machine, an effect will be much magnified in the current cu the self-induction is large and the alternations rapid. That alternating currents are *not* generally sine waves, seems to be indicated by the well-known tions to which electric lights fed with alternating cu are subject. These pulsations are too slow to be due ordinary current alternations, but might be in tim the revolutions of the dynamo. They are so mar the case of one important London installation, that Mr Bourne has observed that a rapidly moving objec not present a continuous blurred appearance as if the action of a steady light, but discontinuous ima that, in fact, if a walking stick be swayed rapidly to a the appearance is as if there were five or six instead only.

It does not appear to have been noticed that self duction, although always delaying the rise or f currents, may sometimes hasten the discharge of a c ser. The current which discharges a condenser has to rise and fall. The self-induction will never del rise so much as it delays the fall, because in the form the potential difference of the condenser is high, w the latter it is low. If the self-induction in the dis circuit be not too large, the condenser will dis quicker than if no self-induction were present it will always be possible to halve the time of disch this way. As a lightning discharge is essentially the s that of a condenser, it seems probable that a lightnir ductor will be only improved by the insertion of self tion. Dr. Lodge has recently shown that an iron con is preferable to a copper one, and has accounted for supposing that the iron conductor has less self-ind than the copper one. It is impossible at present whether this is so or not, but the effect may be du quite opposite cause.

TRAVELLING ARC INSTALLATION FO RAILWAYS.*

BY TH. WECHSLER AND CO., NEUMARKT BEI NURNB

The whole interior arrangement of a travelling lation for railways—consisting of a railway carriage with an engine, tank, boiler, dynamo, lamps, and posts, for use in cases of accidents and emergencies—is in the accompanying illustration, Fig. 1.

In the centre of a breakdown waggon is placed an of the semi-portable type, giving about 12 actual h.p. dynamo, series wound, giving 8 amperes and 360 v placed opposite the flywheel of the engine, and is direct by means of a $4\frac{1}{2}$in. belt. It is mounted on adj screws, to allow for the stretching of the belt. If time the machine has only to feed 4—6 lamps, a motion of the brushes alters the tension to the re extent. For 4 lamps 180 volts is necessary. This taking into consideration loss through long distances. machine in full use for 8 lamps takes about 6h.p.

Above the dynamo, on the wall, is the switch-bo which the wires are led. On this is also an ampere measuring up to 10 amperes, a main switch for the d and a regulator, with resistances for the lamps. switch-board is connected with the poles of the d by thoroughly insulated wires of high conductivity,

* From the *Centralblatt für Electrotechnik*, No. 8, 1888

diameter, and also to two insulators outside the waggon. From these last the connection to the lamps is always made.

At one end of each side of the waggon are placed, when out of use, the 8 arc lamps (8·9 amperes, 1,000-1,200 c.p., burning 8-10 hours). These are hung upon a specially contrived elastic frame, so that they may not be liable to damage from the vibration.

At the side of the waggon are two pulleys with windlasses mounted on brackets; on these are coiled the leading wires, which by this arrangement are easily paid out.

Compartments for fuel, oil, tools, &c., are also provided.

The stoke-hole is lined with strong sheet iron; all the leads are insulated, where passing through the waggon, with vulcanite. Immediately below the boiler is a tank of sheet iron, containing about $1\frac{1}{2}$ cubic metres of water. A part of the exhaust from the engine goes into the tank to warm the water; the remainder goes into the chimney. During transit, or when not in use, the chimney can be lowered.

On the roof of the waggon, a place is also provided for seven lamp-posts during transit, one lamp-post is arranged so as to be easily hoisted upon the platform of the waggon or let down again. The lamp on this lights the space around the waggon, thus forming a small station of itself. On the lamp-posts are two insulators, and two pulleys with steel wires to raise the lamps.

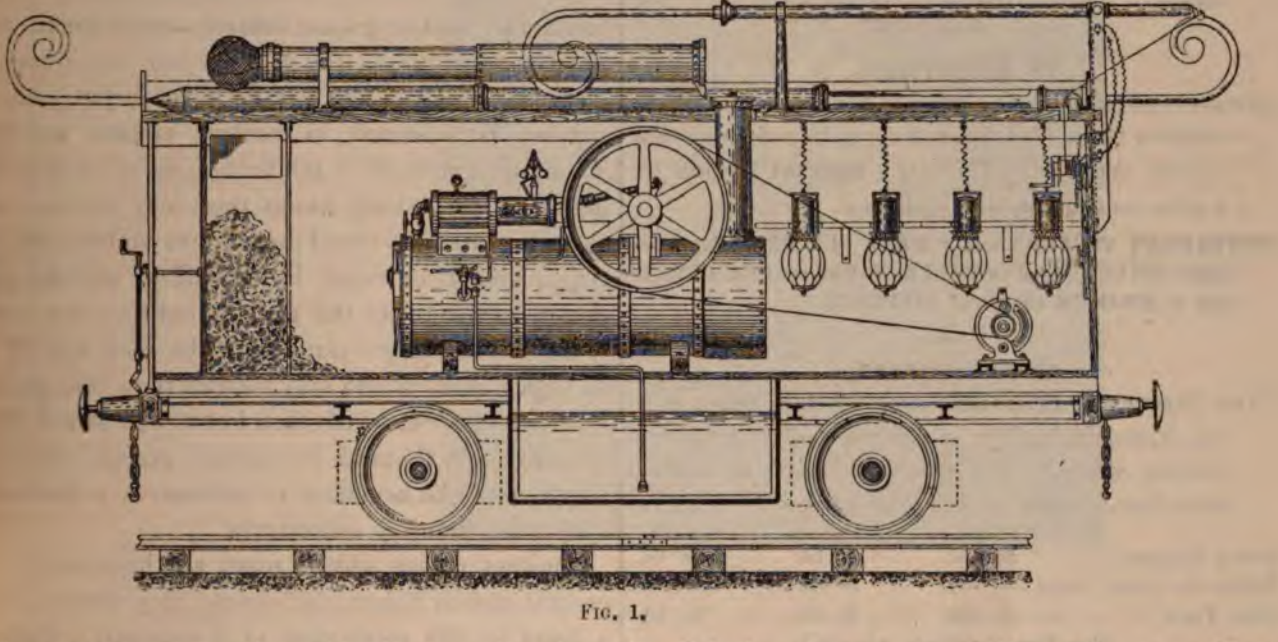


Fig. 1.

These lighting-waggons have the advantage that they can be put in use without delay, and the boiler can be heated during transit to the destination. For this purpose the chimney can be raised or lowered from the inside of the waggon by means of counterweights. There is nothing to do to the lamps but to hang them to the masts. The carbons can also be replaced without danger, as each lamp can be switched off without disturbing the others.

The interior of the waggon is lighted by two Edison glow-lamps on brackets—one to the pressure-gauge of the boiler, and one to the dynamo.

For installation of the lamps in position three men are required; during use, one man.

SIR HUMPHRY DAVY, F.R.S.

With this issue we give a portrait, engraved on steel, of Sir Humphry Davy, who at the commencement of this century held the most commanding position of all England's scientific worthies. Humphry Davy was born at Penzance on the 17th of December, 1779. He was educated at the grammar schools of his native town at Truro. At the age of fifteen he became the pupil of Dr. Borlase, of Penzance, with a view of entering the medical profession, and thus was led to begin the study of chemistry. While with Dr. Borlase, Davy made rapid progress, and entered upon a series of original investigations, the results of some of these appearing in a work published by Dr. Beddoes, who, noticing the talents of young Davy, obtained for him the appointment of experimental chemist at the Bristol Institution. Here he became acquainted with Davies Gilbus, who was afterwards President of the Royal Society. In 1801 Davy came to London, and on the 25th April in that year delivered his first lecture at the Royal Institution. The subject was **Galvanism.** In the month of May following he was appointed professor at the Institution, and at this period his work consisted largely in investigating electrical subjects. The results of his researches were first given to the world in his Bakerian lectures of 1807—1811, and were published in the *Philosophical Transactions* of those years. We shall not enter into the details of Davy's work. To him we owe the discovery of the decomposition of the fixed alkalis by electrolytic means. In fact, he may be said to be the father of the electrolytic branch of electrical science.

From the year 1808 to 1814 the following papers, of which he was the author, were read before the Royal Society and published in their *Transactions*:—"Electro-Chemical Researches and the Decomposition of the Earths, with Observations on the Metals obtained from the Alkaline Earths," and "On the Amalgam procured from Ammonia," read June 30th, 1808—the Bakerian Lecture for 1809; "On some New Electro-Chemical Researches on Various Objects, particularly Metallic Bodies, from the Alkalines and Earths," and "On Some Combinations of Hydrogen," November 16th, 1809; "Researches on the Oxymuriatic Acid, its Nature and Combinations," and on the "Elements of Muriatic Acid, with some Experiments on Sulphur and Phosphorus," July 12th, 1810—the Bakerian Lecture for 1810; "On Some of the Combinations of Oxymuriatic Acid Gas and Oxygen," and "On the Chemical Relations of these Properties to Inflammable Bodies," November 15, 1810, and other papers. One of his greatest inventions was that of the miners' lamp, the first paper in relation to which appeared in the volumes of *Transactions* for 1815, and the last in 1817.

Sir Humphry became President of the Royal Society in 1820, and he continued to contribute papers on subjects of great interest for some time. He was knighted on the 8th April, 1812 (afterwards created a baronet), and he died on May 12th, 1829, at Geneva. Bold, ardent, and enthusiastic, Davy soared to great heights of science; he commanded a wide horizon, and his keen vision penetrated to its utmost boundaries.

Leipzig.—This town possesses two central stations and 21 private establishments lighted by electricity, together comprising 256 arc and 3,459 incandescence lamps.

THE

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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Every Subscriber should with this issue receive a Portrait of Sir Humphry Davy, F.R.S., without extra charge, and failures to receive such Portrait should at once be notified to the Publisher.

NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and this week we give that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S

SHOP LIGHTING.

The owners of a large number of shops have alread adopted the electric light, and many others a anxiously watching the time when they too ma safely give their orders. We have within the pa few days heard of a number of enquiries from trade men as to the first cost and the cost of maintenan of an installation. In most of the cases that hav come before us the expected outlay is stated by th tradesman himself to reach from seven hundred to thousand pounds, so the enquirer does not wish obtain his light for nothing. Most of our large electr lighting firms have agents in various parts of th country, but we venture to affirm that as yet no hou has systematised its plan of agencies. There are n enough of them. It may be difficult to obtain agen of the right calibre, but nothing is ever done witho trying. There is a lack of enthusiasm in the dire tion of small orders. Everyone wants "to bring t house down," that is, to make his reputation and h fortune by handling some central station work. De pend upon it, unless the greatest care is exercised, good many fingers will yet be burnt before gener success is achieved in central station lightin There are hundreds, if not thousands, of electricia going about seeking whom they may devour, b there is scarcely a round dozen that understand th requirements, or could be trusted to satisfactori design a scheme for the general lighting of a sma town. If the larger number of the men who fly so high a game would only restrict their energies those small works which their knowledge and abiliti would enable them to successfully grapple with, th result would be beneficial to themselves individual and to the industry collectively.

Another reason why so many are hankering ov central station lighting is because they want to ha a hand in the promotion of a company. Centr station work will develop naturally; meanwhile, not neglect the little orders. We are not writin for such firms as Crompton and Co. and The Brus Company. They and similar firms can underta any work coming to them. We rather address ou selves to those we think are aiming too high. will be as great a surprise to many of our readers it was to us, to be told that a few weeks ago tradesman who advertised for "electric lighting was severely let alone by those who migl have responded to his appeal. He is building number of shops adjacent to a new one of h own, and by an arrangement with his tenants, pre sent and prospective, has added a moderate amoun to the ordinary rent for the purpose of providing th "electric light." Further, he requires an engine fo his other work, so the matter is simplified to the installing a larger engine, dynamo, batteries, and fitting up the shops—outside with arc, inside with incandescence lamps. Two replies, and two only,

Painted by Lonsdale. Engraved by J. Jenkins.

By permission from the larger Print published by Messrs. Agnew & Zanetti.

SIR HUMPHREY DAVY, BART. P.R.S.

Humphry Davy

were the response to the advertisement, and one of these was from a man utterly unknown in the industry; the other was from a young firm quite capable of doing some excellent work, and fully competent to undertake this special work. The tradesman, however, is used to the comparison of a number of tenders, but was quite at sea as to the value of the suggestions from the one responsible house. Quite accidentally, matters so happened that in all probability the work will be carried out; but no thanks will be due to the score or so of firms who ought to have been eager for such work. The capital of these firms is sufficient to enable them to carry out such work as this well, but insufficient for the larger work that lures them to destruction as the candle does the moth.

Further, in a great many shops there is an earnest desire to make the work as healthy and comfortable as possible under the exigences of modern business. It is, perhaps, a mistake to suppose that the hours are longer now than they were before the introduction of gas, but they have changed somewhat from early mornings to later evenings, and there is no reason to suppose the electric light would be required for fewer hours than is gas. In many cases, gas is far more costly than the shillings and pence per thousand paid for it lead one to suppose. The owners of the shops know this in the quantity of spoiled goods sold at a great reduction, and for this reason, among others, do not object to pay a higher price for a purer light. With regard to the number of hours, our contemporary, the *Warehousemen's and Drapers' Trade Journal*, has the following:—

"'It is an unfortunate thing for tradesmen and their assistants,' said an enthusiastic friend the other day, 'that gas was ever invented.' 'Why so?' we asked. 'Because,' he replied, 'before the introduction of gas for lighting purposes, shopkeepers acted upon the old maxim of "Early to bed and early to rise," but with gas came late and long hours and all their attendant evils, for which we find it so difficult to discover a remedy.' Probably the same conclusion has suggested itself to many of our readers, and if so, they may like to know how far it is correct, for few of us can remember much of business before gas lighting had become common. In the middle of the last century the draper's shop was supposed to be open from eight o'clock in the morning till dark, which would certainly give short hours in the winter and make them very long at midsummer; milliners, we are told, reckoned their hours to be from seven to seven, and mercers from eight to eight, while mantua makers (dressmakers as we call them nowadays) worked from seven in the morning till eight in the evening. Hosiers and haberdashers kept their shops open from seven in the morning to eight at night; while the grocers and oilmen, then as now, two of the special victims of long hours, were expected to keep open from seven until ten o'clock, as also was the tobacconist. For most handicrafts the hours were longer than for tradesmen. The regular hours for tailors and breeches-makers were from six in the morning to eight at night; capmakers, from six to nine; embroiderers, from six to eight; glovers, from six to nine; and for hatters, from nine in the morning to midnight! The regular hours for silk throwsters were from six to nine; and for weavers, generally, from six to eight o'clock. In the long list of trades and occupations before us (given in the 'London Tradesman' for 1751) the most common hours for artisans are from six to eight; though there are some curious exceptions besides those already noticed, as, for instance, the gunsmiths, whose working hours were from five o'clock in the morning to nine at night. It would seem, therefore, that upon the whole the introduction of gas has not had so marked an influence upon the length of business hours as might have been expected, and that, for the most part, closing earlier at night meant commencing earlier in the morning."

It may justly be said that these small installations cannot be as economical as larger ones, and especially will difficulties arise with the accumulators, as they require to be in charge of competent hands. Are the difficulties insurmountable or so great that contractors hesitate to dabble in such business?

THE EASTERN EXTENSION COMPANY AND ITS DIRECTORS.

Although we may be deemed impertinent in attacking directors and balance-sheets of old-established companies, we shall not hesitate to do what we believe to be a duty. It is but a short time since our new evening contemporary directed attention to stock-jobbing or speculation "masquerading in the guise of science." We have no objection to their masquerading in any guise they like, but it must be outside the City of London, and, indeed, outside English business of any kind. Nemesis comes slowly, but generally pretty surely; and it is high time a blow was struck at men whose action, judging from appearances, has always been to consider their own interests first and their shareholders after. The directors' report of the Eastern Extension Company has been issued. From one point of view it is good, in that it promises a six and a half per cent. dividend. From another point of view it is bad, in that the dividend, instead of being only six and a half per cent., should be higher. Our intention at the present moment is merely to cast a doubt as to the perfect bonâ fides of the directors. We want the shareholders to consider why the Eastern Extension exists as a separate company. A little examination will show that, so far as the clerical work of the Company is concerned, it is

carried on by the Eastern Company; that practically the line is an extension of the Eastern; that the interests of the two companies are so bound up together that they must be looked upon as one concern. The directors are, so far as influence goes, the same, but because they work the business as two separate companies they get a double amount in fees. Now, we contend that amalgamation would mean a considerable saving; and we are sure that if any change in the present administration should occurr, amalgamation would be an immediate result. The shareholders, too, might make some pertinent enquiries about the reasons why no "managing director" was appointed after the death of the late managing director. The true reason is that the two parties most interested could not agree. One wanted the position for himself, the other wanted it for someone else. The time has not yet arrived when full light can be thrown upon other phases of management or mismanagement. We believe a great saving would be affected by amalgamation. We believe that the strained relations now existing between the companies mentioned and some of our colonies would cease under a change of management, and there are other reasons far more powerful which will compel a change. We believe that the shareholders could get a higher dividend, the public a cheaper and better service, were the whole of the questions relating to the success of these companies investigated. At the present time we merely point out that the amalgamation of the Eastern, Eastern and South African, and Eastern Extension Companies is becoming a question of urgency.

CORRESPONDENCE.

THE VAN RYSSELBERGHE SYSTEM FOR TELEGRAPHS.

(Translated from the "Bulletin International de l'Electricité" for April 9th.)

"To the Proprietor of the 'Bulletin International de l'Electricité.'

"Sir: In the number of March 26th of your valuable paper you state that the administration of the Swiss telegraphs has given up the Van Rysselberghe system on the line between Basle and Zurich, which had been fitted up as a trial, because the results proved entirely unfavourable.

"We do not know where you may have got that information from, since it is utterly wrong.

"We hold an attestation to the contrary from the chief of the Swiss telephonic network, the publication of which would occupy too much room in your paper, but which we hold at your disposal. It appears from the said document that the two telephonic communications between Basle and Zurich are working regularly.

"On the other hand, it is not on trial merely, as as you seem to think, that the Van Rysselberghe system was applied to the telegraph lines between Basle and Zurich. Its success had long ago been proved in Switzerland. In fact, thanks to the initiative of the Administration of Telegraphs of that country, who had already commenced negotiations in 1883 with our firm for a proposed trial of the system, a telephonic and telegraphic service was opened between Lausanne and Geneva in 1884. At present, from the last official statement, the Van Rysselberghe system is applied in Switzerland on 536 kilometres of telegraph wires.

"Trusting you will be kind enough to publish this correction in your next number—We remain, &c.,

"(Signed) "Mourlon and Co.,
"Licensees of the Van Rysselberghe patents.

"Brussels, April 14, 1888."

[The above letter throws more light upon the subject of our note, p. 290, March 30.—Ed. *E.E.*]

THE CHELSEA TENDERS.

To the Editor of the Electrical Engineer.

Sir: As it would appear from the account of the Borough Surveyor that although we are manufacturers of accumulators, we do not ourselves employ them in our own electric light installations, we would point out that this is far from being the case; in fact, we were somewhat annoyed at the construction which had been put on our proposal, as we had gathered that the chief consideration with regard to this lighting was low first cost and economy of maintenance, and that an accumulator scheme was not wanted. Under these circumstances, we pointed out that it would be unsafe to rely upon one engine, and that a second would be necessary. Our estimate for maintenance was also made higher owing to the number of tons of coal, which we mentioned, being kept the same, whereas a better quality of coal was to be used. This would, of course, have materially reduced the consumption of coal for a given return, so that the coal should have been left as we put it in our estimate, when our maintenance would have come out £16 lower than given.

There is, of course, no question that a more efficient system of lighting would be provided by the adoption of accumulators, but the expense of the lighting would necessarily have been a trifle higher both in first cost and maintenance.—Yours, &c., Drake and Gorham.

LITERATURE.

Turning Lathes: A Manual for Technical Schools and Apprentices. A Guide to Turning, Screw-Cutting, Metal-Spinning, &c. With 194 Illustrations. Edited by James Lukin, B.A. [London: E. F. and N. Spon. 1884.]

The aim of this book is simplicity; and we think the author has succeeded in his endeavour to provide a work that shall describe simply the essential parts of a lathe and the way to use the machine. The book does not err, as too many do, in pretending to be written for beginners, and yet flying to the most difficult parts of the subject just to show the author knows all about it. The lathe in its simplest form is first described, then a number of the more useful chucks, after which the reader is told how to use the gouge and chisel upon plain solid work, and subsequently upon hollow work. Each successive chapter treats of more difficult and elaborate work, introducing, as required, descriptions and manner of using the various tools and lathe accessories needed for the work under consideration. The weakness of amateurs is not overlooked, for we read, page 33, "Where most amateurs fail is in the matter of patience." It is so. Instead of persevering to do the work with the simple tools, the amateur is on the look-out for this or that addition to his lathe to save himself trouble, and get the work done automatically. The professional, on the other hand, has plenty of patience; what he lacks is, generally, intelligence, and the author give him a spur by saying, page 79, that "a workman thus using his intelligence will soon prove a better workman than he was before." The work is well illustrated, most of the illustrations being of actual machines and tools, many of which are the manufacture of the Britannia Company, which has made the construction of lathes a speciality. From our pages last week it will be seen that modified forms of lathes are being designed for winding the armatures of dynamos, and we have no doubt that ere long almost all armatures will be machine-wound. Of course, the ordinary lathe is largely used in all shops, and this little book will form a good introduction to the subject, and should be in the hands of all apprentices and

others who are likely to have such machines under their control.

COCKBURN AND DAY'S SWITCH.

We illustrate herewith a new switch, which has just been designed and made by Messrs. Cockburn and Day. The illustrations almost suffice to explain themselves. Fig. 1

Cockburn and Day's Switch. Serpentine base.

FIG. 1.—On. S shows locking spring.

shows the switch on; Fig. 2 shows it off. As will be seen, when full on, the switch is locked by a spring and catch. On turning off, a quarter turn must be first taken with the finger-piece, when a cam forces down the locking spring;

Cockburn and Day's Switch. Serpentine base.

FIG. 2.—Off. S shows locking spring.

and immediately this is down, the powerful spring of the switch proper comes into action, and breaks contact so quickly that any chance of sparking is reduced to a minimum.

ELECTRICAL TRACTION.

Electrical traction has made great progress since the first experiments, and, according to the calculations of M. A. Bandsept, of Brussels, in a recent paper before the Anciens Elèves des Arts et Métiers, may even now be obtained at the same cost as horse traction. Still, the weight of accumulators, compared with that of the total load to be drawn, appears too great; and it is towards the reduction of this weight that the efforts of inventors should be directed.

An ordinary tramcar is transformed into an electric car by making the outside panels movable, and raising the body. The accumulators are arranged under the seats, and are divided into several series independent of each other, to facilitate the exigencies of traffic. Each series is placed in a drawer sliding on rollers, connected by automatic contacts with the regulator. Elements of the same series have their electrodes connected by soldering, the outside electrodes terminating in two contacts arranged on the plates of the drawer; and these contacts encounter spring plates, which establish communication between the various portions of the system.

In the Julien accumulators the supports of the plates are unalterable, so that their durability is said to be very great. After long service on the Brussels tramways, they show no alteration of form, and are perfectly rigid. The grids are cast of lead, mercury, and antimony—an alloy which is not oxidizable, and has the property of rendering the plate inalterable. The output of the accumulators is very regular, and they are capable, with a relatively small weight, of storing up a large amount of electric energy.

With two sets of accumulators, one in and one out, the car is in a favourable condition for working. It is thus that the automotive cars of the "Electrique" Company took part in the Antwerp competition, and are now running on the Brussels tramways. They weigh about six tons, including passengers and accumulators, the weight of which but slightly exceeds a ton. Recent trials have shown that a car can make a daily run of 50 kilometres, or 33 miles, with a single set of accumulators, the weight per ton per kilometre, therefore, not quite reaching 5 kilogrammes, or 11lb. The set of accumulators consists of four groups of 30 cells, each weighing 12·5 kilogrammes, or 27·5lb., connected in series, and yielding at the terminals, 60, 120, or 240 volts. The current from the accumulators on the heavy gradients of the lines on which the cars are running does not exceed four or five amps. per kilogramme (2·2lb.), and the tractive effect is put at 12 kilogrammes, or 26lb per ton.

According to the results of experiments made on cars with a carrying capacity of thirty places, on several lines, 4 kilogrammes, or nearly 9lb., of accumulator plates are required for the transport of one ton the distance of one kilometre, or 0·62 mile. This proportion gives a gross weight of 5·5 kilogrammes or 12lb., including the boxes and the acidulated water. In most cases, therefore, this figure is taken as a basis for calculating the weight of accumulators necessary for the transport of a given weight for a known distance.

The weight of accumulators which enters into the total weight to be transported necessarily depends on the efficiency of the apparatus employed; and it remains to be seen whether very light or heavier couples should be preferred.

A good set of accumumulators is the essential basis of a rational system of electrical traction, provided it be accompanied by a motor working under favourable conditions, so as to avoid polarization. The use of accumulators lends itself perfectly to the exigencies of service on lines with the steepest gradients. On starting, the current flows in great quantity to the motor, diminishing as the speed of rotation increases. This is just what is required in tramway work. The accumulators permit of regulating this current in proportion to the effort to be exerted.

As has been said, the accumulators are divided into several sets or series independent one of another, there being generally four to a car. These sets are connected with the terminals of a special switch which permits of grouping at will the four sets in parallel, or two to two in series; or the four sets may be connected up in series.

The necessity for frequent recharging is an obvious drawback when automotive cars are used, so that it is advisable to work with as few chargings as possible; and it is towards this desideratum that the working of the Brussels electric cars is tending.

The car which took part in the Antwerp competition weighed 4,250 kilogrammes, or about four tons, and had

1,200 kilogrammes, or rather over a ton of accumulators, with 560 kilogrammes, or 1,234lb. of motor mechanism. The weight of the accumulators was made up as follows:—Plates, 840 kilogrammes = 1,851lb.; liquid, 220 kilogrammes = 485lb.; and boxes, 60 kilogrammes = 132lb. In this example the active substances of the plates weighed only 26 per cent. of the whole. They had been specially made for a line with heavy gradients, one of them requiring a tractive effort of 8 h.-p. The speed of the car was increased from about three to four metres per second at Antwerp.

In another car exhibited there were 96 accumulators, coupled in series of 12. Each cell, of a capacity of 15 ampere hours per kilogramme, included 17 elements, and weighed about 10 kilogrammes, or 22lb., without liquid or receptacle, the total weight of the battery being about a ton. The eight groups only constituted four series—that is to say, there were never more than 48 elements in series. The motor was combined to work with a current of 20 to 30 amperes. A car on the same system running at Hamburg has 14 places inside. The accumulators consist of 15 plates each, and the battery is composed of 96 cells, the gross weight of which, including water and box, is 1,200 kilogrammes = 23½ cwt. The motive-power is three-quarters of a horse-power per kilometre, or, roughly, 1 h.-p. per mile.

In the Julien car the power is proportioned to the load by the regulator, which couples up the required number of cells, and is indispensable to the system. It has the advantage of superseding the artificial resistances used in other systems of electrical traction for regulating the power. One of these regulators is placed on the platform at each end of the car, a loose key for working the switches engaging in a sector provided with teeth, each of which corresponds with a special group of plates.

To change the batteries when exhausted, the car is brought alongside a table or platform, upon which are slid the boxes containing the exhausted accumulators. The car is then pushed forward alongside another table or platform holding the accumulators which have been charged, the terminals pressing against automatic contacts put in communication by leads with the general circuit.

M. Bandsept insists upon the charging station being well and conveniently arranged, as any hesitation or negligence in charging the accumulators leads to considerable loss of time, and he concludes that the future of electrical traction depends in a great measure on the power of the accumulator and a suitable combination of the battery with the motor which it supplies.

PHOTOMETRY.

Captain Abney and Major-General Festing have recently communicated to the Royal Society the results of their experiments on the photometric measurements of the light emitted by glow-lamps. They showed some time ago, that as the temperature of a carbon filament or platinum wire in vacuo was raised in temperature, the rays of light and heat emitted followed a definite law governing their intensity, and that the total radiation, as measured by a thermopile, varied with the number of watts expended, diminished by some constant. They then anticipated that the radiation due to the visible rays increased in a manner which could be graphically represented in the form of a parabolic curve if the abscissæ represent the watts expended, and the ordinates the intensity of the light. In order to see whether this conjecture were a true one, an incandescent lamp, through which a fixed current passed, was taken as a standard for comparison. A second similar lamp was subjected to currents of varying strength, and the light emitted by it was determined in terms of the standard lamp by the Rumford, or shadow, and the grease-spot methods of photometry. Each lamp was connected with an ampere-meter and a voltmeter, and in front of the standard was placed a pair of sectors, whose aperture could be varied by rotation, and worked by an electromotor. The comparison was effected by two methods—the first consisted in cutting off more or less light from the standard light by means of the rotating sectors, and the second by varying the current by alteration of the resistance in the circuit of the lamp undergoing comparison. A considerable number of experiments were made on both of these plans, and also by the grease-spot method, which was found to yield very concordant results. A Woodhouse and Rawson lamp and a Swan lamp were examined by these methods, and results were obtained which prove the accuracy of the law which they predicted. Mr. W. H. Preece, from his photometric experiments, came to the conclusion that the intensity of illumination in a glow-lamp was proportional to the sixth power of the current, and from the results obtained by Abney and Festing it is seen that this empirical statement is exact within certain limits. They have also arrived at the same results by a photographic method. The total light, as measured by a photographic plate, was found by them to vary with the watts producing the light in the same parabolic manner as when the total light radiation is measured photometrically. The results by this last method, however, do not show such satisfactory numbers as in the former experiment, owing to the want of uniformity of all parts of a photographic plate and experiment errors in determining the time of exposure and the density of the plate after exposure.

LAMP-HOLDER.

The accompanying illustration shows a simple lamp-

holder, manufactured in considerable numbers by Messrs. Woodhouse and Rawson. The illustration explains itself.

ELECTRICAL TRAMWAYS: THE BESSBROOK AND NEWRY TRAMWAY.*

BY EDWARD HOPKINSON, M.A., D.SC., ASSOC. M. INST. C.E.

(Continued from page 355.)

There are two generating dynamos of the Edison-Hopkinson type, manufactured by Messrs. Mather and Platt, of Manchester. Each is shunt-wound, and intended for a normal output of 250 volts, 72 amperes, at a speed of 1,000 revolutions per minute; but they are never used coupled, as one dynamo is found to be sufficient for the working of the line. Although the average current for a day's work does not exceed 72 amperes, the current required for starting a heavy train on a steep gradient may be three times this amount. It is essential, therefore, that a dynamo intended for such purposes should not only be mechanically strong enough to develop an output far exceeding its normal output, but also that its design should be such that the variation in the lead of the brushes with the current should be as small as possible, and that the fall in electromotive force as the current increases should not be excessive. The latter condition can be met by compound winding, but, on the other hand, the ease with which shunt machines can be coupled parallel is in favour of their use. It

* Paper read before the Institute of Civil Engineers, and reprinted by permission from the *Transactions* of the Institute.

is also of considerable importance to keep the self-induction of the main circuit as a whole as low as possible, otherwise the sudden variations in current at stopping or starting of the train is a severe strain on the insulation both of the generator and motor dynamos and on the conductor cables. If the generator dynamo were series-wound, or partially so, the self-induction of the circuit would be considerably greater than with a simple shunt-wound generator. Both by reason of the small variation in lead and electromotive force, and also the mechanical strength of the drum form of armature, the dynamos employed are particularly well suited for the purpose, and have given most satisfactory results. The resistance of the field-magnets is 74 ohms, and of the armature 0·12 ohm; consequently, the electrical efficiency, when working with the normal current, is 92·2 per cent., and the commercial efficiency 90·4 per cent.

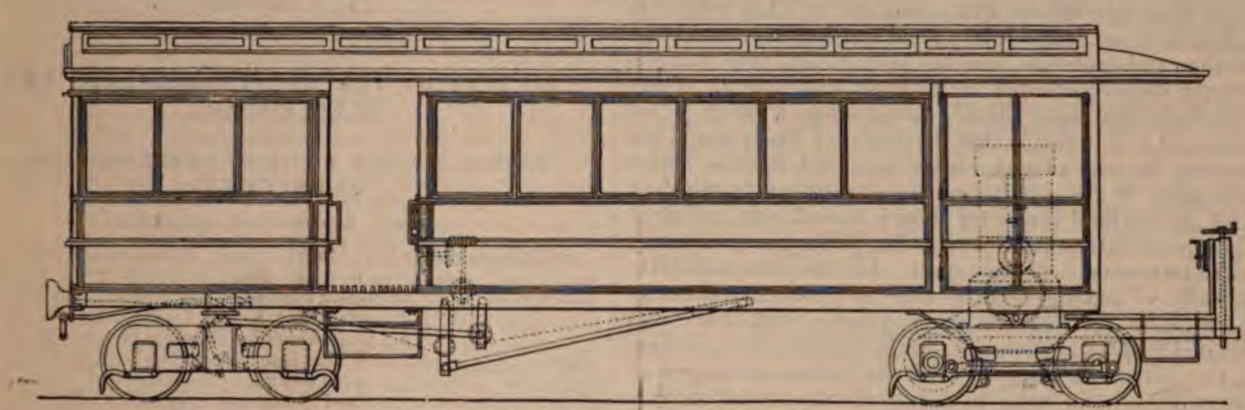
Conductor.

The conductor (Fig. 7) is of channel-steel, laid midway between the rails, and carried on wooden insulators nailed to alternate sleepers. The channel form presents several obvious advantages. It can be obtained readily in a variety of stock sections without being specially rolled for the purpose. It does not require to be secured, but can be simply laid on the insulators, which fit into the channel and, while allowing longitudinal motion to compensate for changes of temperature, hold it laterally. It is also a most convenient section for making the joints between consecutive lengths. The joints must be sufficiently strong mechanically, and at the same time offer no electrical resistance. Double fish-plates placed externally on either side the webs are sufficient for the first object, but the rust between the surfaces in contact often causes almost complete insulation. The electrical connection is therefore made independently by a strip of soft copper of such section that its conductivity is about the same as the steel. It is bent in a U form to allow for the expansion and contraction of the channel. These strips are riveted in the channel with double copper rivets, care having been taken that the hole in the channel was perfectly free from rust before the riveting. At the several crossings of occupation roads, twelve in number, the electrical continuity of the conductor is broken by insulating a section of the channel, and the current is conveyed by a cable laid beneath the sleepers. The top of the channel being level with the rails, the intervening space can be paved or planked, thus making a good roadway without interfering with the mechanical continuity of the conductor. As none of these crossings exceed in width the length of the locomotive cars, the leading collector makes contact on one side the crossing before the back collector breaks on the other. The cables are of stranded copper wire, consisting of thirty-seven No. 14 B.W.G.—1st, cotton lapped and varnished; 2nd, heavily covered with pure rubber; 3rd and 4th, double served with best rubber separator; 5th, covered with pure rubber; 6th and 7th, taped with double-served proof tape, the cable then vulcanised and made water-tight; 8th, lapped with thick serving of tarred hemp; 9th, braided overall and heavily compounded.

In constructing a conductor of iron or steel, it is of the utmost importance to specify the composition. Steel may be obtained with a specific resistance, varying from 0·00001 ohm to 0·00007 ohm, according to the amount of carbon, silicon, and particularly manganese.* The steel used was manufactured by the Darlington Steel and Iron Company, and specified not to exceed in carbon 0·15 per cent; silicon, 0·05 per cent; manganese, 1·00 per cent. The actual composition according to the makers' analysis is: carbon, 0·09 per cent; silicon, 0·02 per cent.; manganese, 0·63 per cent.; and the specific resistance 0·0000121 ohm. The weight per foot of the conductor is 4·33 lbs. (6·46 kilogrammes per metre), and the section 1·367 square inch (8·817 square centimetres). The cost, delivered at the wharf at Newry, was £7 10s. per ton. High conductivity copper could not at that time be bought under £84 per ton, with a specific resistance of 0·0000016 ohm, showing a gain in favour of steel over copper, having regard to weight and conductivity, in the ratio of 3 to 2.

At one point the lines crosses a country road obliquely, the crossing being 150ft. in length. The method before described of bridging the gap was here not feasible, and it

Fig. 4.



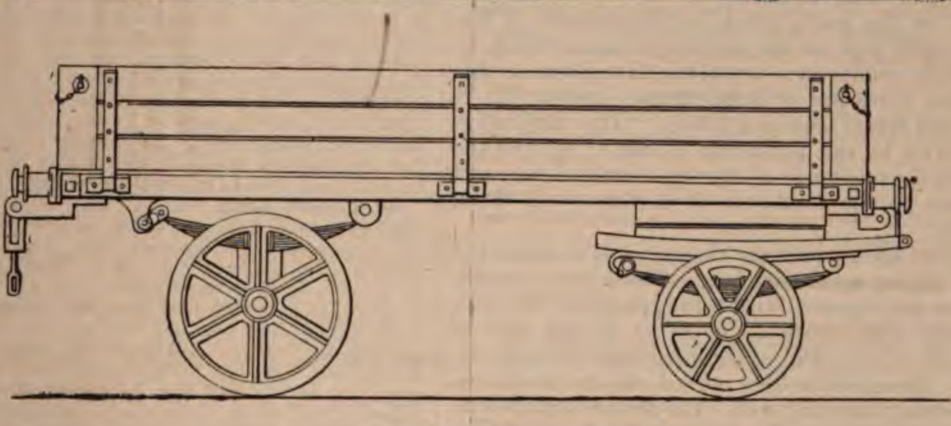


Fig. 5.

* "Magnetization of Iron." By John Hopkinson. Phil. Trans. 1885 vol. 176, p. 463.

was necessary to resort to some other device. A copper wire was slung centrally between the rails from cross-bars carried on posts, placed on each side the rails at either end of the crossing, the lowest part of the catenary being 15ft. above the road level, to meet the requirements of the Board of Trade. An overhead collector, formed of bar iron, fixed above the roof of the car, passes under the cross-bar, and immediately makes contact with the wire before the back collector leaves the ground conductor, and continues to make a rubbing contact until the leading collector has again made contact with the ground conductor on the other side the crossing. This method of carrying the conductor and making contact with it was devised in 1885 by the author's brother, Dr. John Hopkinson, and has proved in every way a most complete success. The collector on the roof of the car, though merely a bar of flat iron 1in. wide, greased with tallow once a week, makes a perfect contact with the copper wire sufficiently good for transmitting 120 amperes. After an experience of two years there is no perceptible wear on the wire except at the point where it is picked up by the collector, and even here it is very small. An overhead conductor has many advantages over one placed on the ground-level or beneath. There is no interference with crossings; it is less subject to malicious or accidental injury; and, particularly, perfect insulation and isolation can be secured, enabling currents of much higher potential to be used with safety. There is no doubt that some animals cannot stand a shock of 300 volts, and it is probable that the Board of Trade would not sanction the use of any higher potential, if there was a possibility of the conductor being accidentally touched. With an overhead conductor there is no such risk, and much higher potentials would be permissible, giving greater economy in the transmission of the power. On the other hand, the difficulty of making contact with an overhead conductor has hitherto opposed almost insuperable difficulties, now obviated by this simple device. In the crossing above referred to, two catenaries are used with the points of support at different levels, in order to reduce the tension of the wire and the pull on the posts, which, in this instance, is not balanced by a like pull on the opposite side, as would be the case were the conductor constructed throughout on this principle. The wires are of hard, drawn copper, No. 4 B.W.G., and the actual tension is 120lb. The inclination of the catenaries to the horizontal is $\tan.^{-1}\frac{3}{35}$, and the collector clears the underside of the cross-bar by $5\frac{1}{4}$in., and therefore picks up the conductor at a distance of 64in. from the posts.

The insulators upon which the channel-steel is supported are blocks of poplar wood 5in. long. These are carefully dried, and then impregnated with boiling paraffin. A block of dried poplar will absorb as much as 75 per cent. of its own weight of paraffin, which permeates through the whole mass. These blocks have proved efficient insulators, and are apparently standing well. The actual measured insulation of the conductor, under unfavourable circumstances as regards weather, and when charged to a potential of 250 volts, is about 900 to 1,000 ohms per mile, approximately the same as the author obtained at Portrush.* Such an insulation is sufficient for practical purposes. It represents a loss through leakage of $\frac{1}{4}$ ampere, or one-tenth of a horse-power per mile. The actual measured leakage current of the whole line in wet weather amounts to nearly four times the above amount, the excess being probably due to some slight fault in the cables and arrangements at the points and crossings.

The circuit is completed by the rails of the permanent-way, which are uninsulated. As is the case with the conductor, the fishplate connections are not sufficient, and are supplemented by flexible copper strips riveted to the under surface of the rails. The specific resistance of the steel rails (Barrow Hematite) is 0·0000166 ohm, and hence the total resistance of the four rails, having an aggregate area of 12·4 square inches, is 0·033 ohm per mile. The resistance of the conductor is 0·221, making the resistance of the circuit 0·254 ohm per mile. Allowing for the earth and for some contact resistance, probably 0·25 ohm per mile fairly represents the average resistance (0·156 ohm per kilometre). The electrical connection of the rails of the permanent-way is essential, since the earth connection is of little value, as the rails are practically insulated by the sleepers and dry ballast. A curious confirmation of this occurred during a severe thunderstorm. At the first flash, a man employed at the Newry end of the line, who was touching the rails, but not the conductor, and standing on wet ground, received a smart shock, and simultaneously with the lightning flash the attendant observed a blaze of light from the earth-brush of the generating dynamo. At the second flash a similar discharge was observed at the brushes, and at the third flash, more intense than the others, the same occurred again, and the fusible plug connecting the conductor with the dynamos gave way, and two men engaged at the Bessbrook end of the line and touching the rails, but not the conductor, received severe shocks. Clearly, in each case the system, as a whole, had been struck, and the charge was making the best of its way to the earth. After this occurrence the precaution was taken of connecting the rails of the permanent-way to the earth at several points.

(To be continued.)

* Mr. Holroyd Smith, with an underground conductor, found the leakage current to vary from 30 to 100 amperes, with an electromotive force of 220 volts, showing an insulation resistance of 4·4 to 13·2 ohms *per mile.*

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

CENTRAL STATION LIGHTING.—TRANSFORMERS v. ACCUMULATORS.

BY R. E. CROMPTON, MEMBER.

Mr. Crompton, at the end of his paper (given in our last issue), stated that he hoped the members would give him credit for having endeavoured to be absolutely fair to the two systems. He had given everything to the A.T. system that he could give it, and for the B.T. system he had taken figures which he was quite prepared to adopt in practice, and, in fact, they were based upon his actual experience. He denied the statement as to his being a recent convert to accumulators, as he was the first in England to mention Faure's discovery, in which he had great hopes. He used accumulators largely at the Law Courts, but got tired of them, as they did not work satisfactorily. They had, however, been much improved, and were in a better condition for electric lighting than for any other work they were called on to do In unskilful hands accumulators were difficult to manage. He had 1,350 E.P.S. cells in work at Vienna, which were of the older types, but worked satisfactorily. He strongly impressed upon the meeting that accumulators could at the present moment do the work remarkably well with an extremely small loss.

Mr. Gisbert Kapp thought that the makers of accumulators could not have found a better advocate for their system than Mr. Crompton. Accumulators were originally planned for the Victoria installation, but they were never fixed, probably on account of their unreliability. He was glad, though somewhat surprised, to hear that they were now reliable. In his remarks he might have to differ from him, but he much admired the plucky way in which Mr. Crompton had fought the battle of accumulators against transformers. He had made an impression upon his (Mr. Kapp's) mind, and he was still open to conviction when he saw the installations offered by Mr. Crompton to substantiate his words. He did not consider a maximum output of 3,600 units per day too much for a plant which could supply 600 kilo-watts at the lamps, and the reason why the London diagram exhibited by Mr. Crompton was lower than those for Boston and Cincinnati was no doubt due to the supply to theatres and public halls being low. He agreed with Mr. Crompton that there was something more than the price of copper to be taken into account when speaking of the cost of a conductor, but Mr. Crompton had erred in adopting figures which were in excess of the price at which cables could be purchased. A twin main would cost £130 for 100 yards, whereas Mr. Crompton had taken £187. If lead-covered cable could be placed directly in the ground with a plank covering to warn workmen that it was underneath, the cost of laying would not be more than 3s. a yard, so that with £10 for surface boxes the total cost would be £155 for 100 yards against £187.

Mr. R. E. Crompton said his figures were those found to be incurred by actual experience.

Mr. Gisbert Kapp: The insulation of the lead-covered cable would be measured by megohms, while that provided by Mr. Crompton would only be a few hundred ohms, or a thousand ohms per mile. A cable in Milan, for the Edison Company, gave 500 megohms per mile, and others laid for the Thomson-Houston plant there gave 1,200 to 1,500 megohms before being laid, and 350 megohms when laid and jointed. Another Edison cable in Milan, having two conductors, was laid in June, 1885, and continued to work to the present day with only one interruption, which was due to an experiment with alternating currents. He would rather not be the engineer responsible for keeping up the insulation of naked conductors, especially when a saving of 5 per cent. on Mr. Crompton's estimate could be effected by using the Berthoud-Borel cable. In his distribution the plan he advocated was to use high-tension cables for the feeders and low-tension cables for the network of supply. He did not pretend

ELECTRIC LIGHTING ACT.

At a recent meeting of the electrical trade, held at the offices of the Anglo-American Brush Electric Light Corporation, Limited, it was decided to petition in favour of Lord Thurlow's Bill now before the House of Lords to amend the Electric Lighting Act of 1882, and the following petition has been extensively signed by the principal electrical companies and firms, and by gentlemen representing the scientific interests of the industry :—

In the House of Lords, Session 1888.

ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

PETITION IN FAVOUR OF THE BILL.

To the Right Honorable the Lords Spiritual and Temporal in Parliament assembled.

The most humble petition of the companies and persons being traders and persons interested commercially and scientifically in the subject of electric lighting in the United Kingdom, whose seals and names are hereunto attached and subscribed.

1. A Bill is now pending in your Lordship's House intituled "An Act to amend the Electric Lighting Act, 1882," and having for its especial purpose the extension from 21 to 42 years of the period limited by the aforesaid Act of 1882, after the expiration of which, local authorities may have an option of purchasing electric lighting undertakings within their district, and being in respect of the aforesaid extension of time based upon the report from the Select Committee of your Lordship's House on various Electric Lighting Bills in the year 1886.

2. Your petitioners claim to represent the commercial and scientific interests of the United Kingdom on the subject of electric lighting, and are of opinion that the proposed extension of the aforesaid period, and other amendments of existing law proposed by the said Bill, will so far lessen the restrictions which have hitherto prevented this industry from developing as to enable at least some progress to be made in its development.

3. Another Bill has been introduced into, and is now pending in your Lordship's House, intituled "An Act to Amend the Electric Lighting Act, 1882," and bearing the short title of "Electric Lighting Act, 1882, Amendment (No. 2) Bill," the object of which is to effect far-reaching changes in the existing law, which, while they might very possibly attain the object in view, raise weighty and complex questions connected with the powers of local authorities, and your petitioners are very apprehensive that the discussion of these questions must necessarily lead to further delay in affording relief of which the public, desirous of having the advantage of electric lighting, and the electric lighting industry is so urgently in need. Your petitioners therefore respectfully submit that the Electric Lighting Act, 1882, Amendment Bill firstly hereinbefore referred to, which is based as aforesaid upon an exhaustive inquiry which has already been held, ought not to be delayed pending any inquiry which may be considered necessary into the proposals contained in the Electric Lighting Act, 1882, Amendment (No. 2) Bill, and that if the proceeding with the last-named Bill would have this effect, it should not be proceeded with.

Your petitioners therefore most humbly pray your Lordships that the Electric Lighting Act, 1882, Amendment Bill may be allowed to pass into a law in the course of the present session, and that the Electric Lighting Act, 1882, Amendment (No. 2) Bill may not, so far as its proceeding will delay the passing into law of the previous Bill, be allowed to proceed.

And your petitioners will ever pray.

PARLIAMENTARY INTELLIGENCE.

ELECTRIC LIGHTING ACT (1882) AMENDMENT (No. 2) BILL.

In the House of Lords on Tuesday last,

The **Earl of Crawford**, on rising to move the second reading of this Bill, remarked that he did not intend to weary their lordships by going into the former discussions upon this subject, and that the Bill was rather more extended than any previous measure relating to electric lighting. He would, however, briefly explain the changes which he proposed to introduce into the law on this subject. Under the second clause of the Bill the persons who were known as undertakers, and who provided currents of electricity for the purpose of distribution to individuals within a certain area, would be permitted to make their arrangements with the local authority as a licensing authority without having to go to the enormous delay and expense of going to a central office for a provisional order, and of having that order subsequently embodied in a special Act of Parliament. The cost of the provisional order system and the Parliamentary procedure consequent thereupon was undoubtedly very high, and, in addition to that, there was the grave objection that that course of action could only be taken during a certain portion of the year. Unless everything was not foreseen for the next six months, no work practically could be proceeded with until a new provisional order was obtained. We had to go now into a very much larger question than was contemplated in 1882, when this Act became law. In addition to the method of procedure by license, provisional order, or special Act, the present Bill would enable the local authority to enter into an agreement with, and to grant permission to, the undertakers for their several works and purposes as set forth in this Bill. In the event of the local authority refusing, the Board of Trade would be authorised to step in and to say whether that refusal was a just and a right one or not. Clause 3 went into the question of the description of the supply, and proposed that it should be given only under certain *rules to be* laid down by the Board of Trade. The application of electricity for lighting purposes had been in use for six or seven years, and in consequence of the demand the Phœnix Insurance Company started in 1882 a printed set of rules for the guidance of persons who were using the electric light. By carefully following those rules, accidents might, as far as possible, be avoided. The rules were first published in the *Times* in May, 1882. He had made it his business to inquire whether there was any additional risk placed upon buildings which were lighted by electricity or in which the electric light was employed. He was informed by the Phœnix Office that no extra premium was charged on buildings prepared for the reception of electricity under the rules they had drawn up, even though other modes of lighting were also used. In regard to the question of safety for life, he was informed by the Pelican office that where a building was wired in accordance with the rules laid down by the fire insurance offices, they considered that there was no greater danger to life than there would be in an ordinary dwelling-house. Therefore he said that the Board of Trade, in framing any rules for the guidance of undertakers, ought to give great weight to the rules which had already obtained during so many years, and which were drawn up by those who were thoroughly acquainted with the subject. Clauses 4, 5, 6, and 7 of the Bill were practically taken from the Gas Act of 1847, which was incorporated in the Electric Lighting Act of 1882 as far as those clauses were concerned. Those clauses contained all that was necessary in regard to the powers to be given to undertakers in taking up streets in passing from one part of a town to another. Clause 7 gave the local authority the power in all cases to do the work of breaking up the streets and reinstating them. Clause 10 was intended to give a legal status to telephones, which were now doing such valuable service, and to protect them from all possible damage by an electric lighting undertaking. He also proposed that when the undertakers were not the local authority, but a company or private individuals, they should pay a certain sum per annum to the relief of the rates for the privilege of being allowed to use the streets. He would suggest that the sum so to be paid should be £20 a mile, and in Committee—if his Bill should go into Committee—he should be prepared to state the amount which that rate would realise if London were properly dealt with. Their lordships would be surprised to learn to what extent the rates of London would be relieved if this were done. The Act of 1882 prescribed the periods within which the works of an electric lighting undertaking were to be finished. He would propose to leave that question to be settled between the local authority and the undertaking. The next thing was that within five years from the passing of the Act, all cables, or wires, or mains for electricity should be placed underground. Clauses 16 to 23 he had adopted from the Gas Act of 1871, and they regulated for the instruction of inspectors the methods of testing and the supply of the current to the consumer. Clauses 24 to 27 were necessarily of a temporary character, as they related to the character and quality of the supply, which at present there was no instrument accurately to test. He hoped to be able to work out in the laboratory a means of "standardising" the measurement and the current. Clauses 38 to 44 dealt with measurements, and he hoped to induce the Government to make a small addition to the Weights and Measures Act for the purpose of putting technical meters on the same footing as gas meters. In dealing with the supply to be furnished to the general public, he had followed the lines of the Gas Act, 1871, so that every householder within 25 yards of the distributing main should have a right to a current of electricity, and the undertakers should be under similar obligations to those of gas companies. He had also given the undertakers, subject to certain conditions, the power of withdrawing the supply on account of the use of a dangerous or objectionable lamp. Clause 32, also following the Gas Act, gave a local authority power to require a supply if they were within 50 yards of a current. Clause 33 dealt with the question of penalties. He did not desire to invest the electric lighting companies with any permanent monopolies; all that he asked was that they should be placed in no worse position than they were in when they first entered into their contracts. He hoped that the Bill would now be read a second time, that a great industry which had been kept back for six years, since the Act of 1882 was passed, would have room to exercise their capital. He knew of his own knowledge that if the law were made somewhat on the lines of this Bill, that in the course of six or eight months large sums of money would be thrown into the country, and employment provided for large numbers of working men. He believed that 40,000 men would speedily be employed in preparing these works and upon the business of electric lighting. In conclusion, he would only add that, in preparing this Bill, he had kept himself entirely free from any bias in favour of the electric companies, and he had endeavoured to take a fair view of what was due to the local authorities and the gas companies. He had, in fact, tried not to be a partisan one way or the other, and he trusted that this Bill, the second reading of which he begged to move, would meet with the approval of their lordships as being fair and equitable (cheers.)

Lord Thurlow said, while agreeing with much which had fallen from the noble earl, he did not find himself in a position to withdraw his Bill on this subject. It was only a large amelioration in the existing law which would set the large amount of capital ready for investment free. Ever since the Act of 1882 firms and companies of electric engineers and others interested in the subject had petitioned Parliament for such modifications in that Act as would remove those restrictions, which, it was alleged, had the effect of crippling the progress of electric lighting; and in a petition which was presented to their lordships' House yesterday those gentlemen had expressed a view, which he shared, that a Bill so complex in its character as that of the noble earl's stood but a faint chance of finding acceptance, if not in this House, at any rate in the other House of Parliament. Having regard to the circumstances and the subject matter, he had no hesitation in saying that the petition embodying that view was signed by as representative and influential a body of names as could be brought together. The second reason why he was unable to withdraw his Bill in favour of that of the noble earl was that it was too soon after the great Act of 1882

ive the whole question. All that was wanted was a simple measure ief to the companies, giving them a larger measure of time in to recoup themselves for their original outlay, so that they shoud compelled against their will to charge their clients a prohibitive for the electricity which they supplied. A measure of such pro- ns, dealing with public questions so complicated and important, , moreover, to be brought in on the advice of the Board of Trade, he other Government department, in order to do complete justice the interests at stake. His third objection was that it legislated any points of detail which should be left to be dealt with by pro- al order according to the measurements and requirements of each Lastly, with regard to the purchase clauses, he objected to the that it did not recognise the absolute right which the local autho- hould have, in his opinion, to become the purchaser on fair terms undertaking of a private company supplying electric light within ea of such authority.

Earl of Onslow said the speech of the noble marquis on the on of the second reading of his noble friend's Bill would have that the Government were sincerely desirous to do what they to promote the extension of electric lighting; and if it had been n that the Bill now before their lordships represented the feeling ose interested in promoting electric lighting in this country, it have deserved a more attentive consideration; but, as had been inted out, a petition had been laid upon the table, signed by a er of leading firms in the trade who would be most likely to to negotiate with the local authorities, and that they were ed with the Bill of the noble lord opposite (Lord Thurlow). He further say that since the Government consented to the second g of the Bill of his noble friend opposite, there had been a very number of applications to the Board of Trade in the hope the extension of time from 21 to 42 years would have the effect ucing capitalists to embark money in these undertakings. This roposed to make an important change in the existing law. rto Parliament had declined to allow companies promoted, whether rposes of electric lighting, gas supply, or tramways, to make bargains for themselves without the supervision and consent of ment. But this Bill proposed to abolish the provisional order ther, and the noble lord only proposed to do it in the case of the ic lighting companies. There were, he admitted, proposals in ill which were commendable. No doubt it would be a great tage to secure, within a reasonable period, that those overhead which were a danger and disfigurement to the metropolis should l underground. In the Bill of the noble earl there was no pro- for any penalty upon any company which failed to carry out the al of wires. Again, hitherto it had been a practice that the rity or individuals liable to repair certain streets within the area undertaking which were not repaired by the local authorities, l be able to appear before the Board of Trade and state their ions as well as the promoters, and those streets were then placed hedule to the order. As he understood the Bill of the noble earl, persons would not under it have the opportunity of appearing any authority, and would have to submit their case to arbitra- The principle which Parliament had always enunciated was, o monopoly should be set up; they had had sufficient experience result of creating a monopoly in gas, water, and other matters. is Bill it was stated that nobody should have any permanent poly; but from the word "permanent," he gathered that there be a temporary monopoly—*i.e.*, while the order ran; and the earl had omitted to state any time for the duration of the order. regard to the clause which proposed to give local authorities to purchase, he thought that it would have been better to set that question in a more direct manner. With regard to the er in which an undertaking was to be acquired by the local rity, hitherto Parliament had laid down the principle that the rty which the undertakers sold at the expiration of the period ed should not contain any requirement for the goodwill of the n. In order to get over that difficulty, the noble earl pro- to apply the same principle to his Bill as was applied e case of Indian railways and similar concerns—namely, the price should be five years of the marketable value us to the notice to acquire the undertaking. It was possible the company which sold might be a public company, with , the value of which was quoted on the Stock Exchange, and rice would be readily ascertained; but if it were a question of rate company or an individual, there would be no such means ertaining the value. Again, there were many companies which up electric lighting as a part only of their business; in that case it obviously be difficult to separate the value of the electric light ss from that of the other business. This Bill proposed to confer irely new power on the local authorities. It should be remem- that these authorities were undergoing a very great change, and s very doubtful whether it would be wise to confer upon ng authorities powers such as these; in his opinion, the sed county councils might very reasonably be jealous of of these powers being conferred upon smaller authorities. It npossible to discuss in committee of the whole House all the icated and technical proposals of this Bill. Although it was true many committees had sat to consider this question of electric ng, still they had not dealt with all the technical and difficult ons set out in this Bill. As he had said before, the Government nxious to do all that they could to encourage the investment of l in electric lighting, and although he had stated several grave ions to the Bill of the noble earl, he did not wish to throw any ragement in the way of the increase of electric lighting. He ht, therefore, that this Bill might be allowed to go through its reading, and then he would suggest to the noble earl that it be referred to a Select Committee, and that on the report of that Committee the next stage of the Bill should be taken.

d Herschell was glad to hear that the noble earl who had just did not intend to oppose the second reading of the Bill now before them, because it involved questions of considerable interest and importance; and if some alteration were made in it, it would not be inconsistent with the passing of the other Bill dealing with the subject, which had received its second reading. He would regret extremely, however, if this Bill were made a ground for postponing the progress of the Bill to which he had referred, because the Bill of the noble earl no doubt raised very complicated questions which would mean minute discussion and examination, and he was anxious lest the effect would be to hang up this question to an indefinite period and prevent any legislation on the subject passing at any early date. With regard to the petitions which had been referred to, he believed that they were directed towards supporting the scheme which was already in progress rather than to opposing the Bill of the noble earl. There was no doubt that the Act of 1882, with regard to the terms of purchase, needed amendment. It was not the case that whether the terms were onerous or not was a matter affecting only the promoters and the local authority; apart from the question of whether they could make the terms such as to induce capitalists to put money into electric lighting, he thought that the public had a distinct interest in seeing that the terms were not too onerous, as the undertakers would seek to recoup themselves by charg- ing more than they otherwise need for the electric light. That meant that the present generation was to pay more than they otherwise need for the electric light in order that the next generation might get it for less than they ought. He hoped, therefore, that the measure of his noble friend, which had already been read a second time would be allowed to proceed. At the same time, he hoped that the Bill of the noble earl would be read a second time. Owing to its complicated character, he thought there was little chance of its passing through the House this session.

The Bill was then read a second time.

COMPANIES' MEETINGS.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY.

The ordinary general meeting of the Montevidean and Brazilian Telegraph Company, Limited, was held on Monday at the office, Tokenhouse-buildings, Moorgate-street, Dr. Cameron, M.P., in the chair.

The report of the Directors for the year ended December 31 stated that the percentage of gross revenue receivable from the Western and Brazilian Telegraph Company had been £2,508, as compared with £2,370 in 1886. They were glad to observe that, so far as could be judged from the published returns from the Western and Brazilian Company, there appeared some prospect of a greater improvement in the traffic during the current year. The debentures issued in 1876 were made redeemable on the 1st July, 1896. There being a balance of £10,280 still unredeemed, it would be necessary to set aside annually a larger sum for the purpose of redemption than hitherto, and they therefore proposed to appropriate £1,000 for that purpose for the year 1887. Out of the balance of £474 they recommended a divi- dend of 1s. per share on the preference shares, leaving £58 to be carried forward. Mr. James Joicey, M.P., had been elected a director to fill the vacancy caused by the death of Sir T. Gore Browne.

On the motion of the **Chairman**, seconded by Lieutenant-Colonel **G. W. Macauley**, the report was adopted.

COMPANIES' REPORTS.

THE "PILSEN," "JOEL," AND GENERAL ELECTRIC LIGHTING COMPANY, LIMITED.

Report of the Committee of Investigation appointed by resolution of shareholders at an extraordinary general meeting, held on the 13th March, 1888, to investigate the statements contained in the Directors' notice, dated 3rd March, 1888, convening such meeting, and to confer with the Directors, and to report thereon, and generally upon the business of the Company.

The statement in the Directors' notice, dated 3rd March, 1880, that the amount of the working capital of the Company amounts to but £7,093, is taken from the last report and balance-sheet, issued on the 10th November, 1887. This sum of £7,093 is made up in such balance-sheet of the items of :—

Cash (including £2 986 6s. Consols)		£3,037 9 0
Stock, plant, stores, &c.		3,874 0 11
and the difference between		
Debtors to the Company	£966 3 11	
and Creditors of the Company	784 13 5	
		181 10 6
		£7,093 0 5

As to the above item of cash, this has practically disappeared, as the whole of the Consols have been sold out, and the proceeds expended by the Directors, and the cash at the bankers at the commencement of this investigation was the sum of £140. 17s. 6d. only. As to the item of stock valued at £3,874. 0s. 11d., this is the Directors' estimate of the value of the whole of the stock, plant, and stores, &c., of the Com- pany. As the three installations of the Company alone, at which a part only of such stock, plant, stores, &c., are employed, were earning, as stated in the last balance-sheet, a yearly rent of £3,485. 0s. 6d., and are now stated to be producing a gross yearly income to the Company of £5,000, it has been considered necessary to check this estimate of £3,874. 0s. 11d. by taking stock of the whole of the existing stock, plant, stores, &c., of the Company, and this has been very carefully

done, with the following results, which it has appeared convenient to classify as under :—

	Producing per annum.	Original cost to Company.	Directors' valuation.	Present valuation.
Stock, &c., at Bethnal Green Installation—	£1,200 0 0	£2,158 10 11	£416 14 7	£1,482 5 7
Stock, &c., at Whetstone Park Installation—	£1,558 0 0	£4,564 0 0	£900 18 0	£4,500 0 0
Directors' estimate of additions since June, 1887—	—	—	£2,328 5 11	
Stock, &c., at Stanhope-street Installation—	£1,156 13 4	£2,116 14 3	£1,193 19 0	£1,819 1 9
Stock, Plant, Stores, &c., at Stanhope-street Factory—	—	£3,413 19 6	£1,022 0 0	£2,093 9 0
Stock at Agents and on Hire—	—	—	£340 9 1	£340 9 1
	£3,914 13 4	£12,653 4 8	£6,202 6 7	£10,235 5 5

There has been great difficulty in arriving at the above figures in consequence of the unsatisfactory mode in which the books of the Company have been kept. There has been no stock ledger and no store ledger kept since 1884. There has been no stock book kept since 1884, except that the stock list of 1887 has been copied into a book. But the stock lists and valuations, it is stated by the Secretary, have been kept separately for each of the years 1884, 1885, and 1886, and he states that such stock lists and valuations for the years 1884 and 1885 cannot be found, and they have not been produced. It has therefore not been possible to trace or account for the stock from the year 1884, which in the balance-sheet of that year was then valued by the Directors at the aggregate sum of £29 876. 8s. 4d. It is presumed that the shareholders do not desire to have in this report the details (which are very intricate and elaborate, and can be supplied if desired), but only the results of the investigation ; and in obtaining the results which are here presented to them every care has been given to make all due allowances for wear and tear and other circumstances of depreciation. Having regard to all such considerations, the value of the now existing stock, plant, stores, &c., of the Company is believed to be the above sum of £10,235. 5s. 5d. In examining the valuation of such stock made by the Directors, it has been found that the stock, &c., has been most seriously under-valued. For example—a large number of Pilsen arc lamps in perfect order and in full working at installations, and each earning £20 yearly and upwards for the Company, figure in the Directors' valuation for 5s. 9d. each. The price list for such lamps is £12 each. The glass globes cost 10s. each. If sold by auction, these lamps realise from £5 to £7 each and the mere value of the metal, if broken up and sold as scrap, is 5s. 2d. The sum of £3,874 0s. 11d. fixed by the Directors as the value of the stock, was arrived at by valuation in June, 1887, and there has been since that date certain additions to such stock, but Consols have been sold out by the Directors in the years 1887-8, which have realised £4,769. 7s. 5d. In conference with the Directors as to the mode in which this sum has been disposed of, the only explanation given was that it had been spent upon the business of the Company as would appear by the balance-sheet to June, 1887, and by the cash-book. To enable the shareholders to determine how far this explanation is satisfactory, it has been considered necessary to prepare an analysis of the cash-book, and in order that the years in which such a sum of Consols was expended may be compared by them with the years in which no Consols have been expended, the analysis has been carried back to the year 1884, and accompanies this report. The analysis is strictly compiled from the Company's cash-book, and the attention of the shareholders should be directed, amongst other things, to the fact that, although the income received by the Company from "sales of plant, &c.," has enormously decreased, the outgoings for "rent, rates, and taxes, purchases of stock, &c.," and "wages" have varied but little comparatively. Also that in one year £1,092. 11s. 1d. was expended in law costs, while the largest dividend paid in any year is £821. 18s. 8d. Also that a sum of £2,500 appears in the cash-book as a loan to "Ellis and Co.," and in conference with the Directors this is explained by them as having been lent to those gentlemen by the Directors with the object of obtaining 3 or 4 per cent. interest from them. This lending of the money of the Company by the Directors to individuals appears to be wholly irregular and unauthorised by the articles of association, and, moreover, upon investigation by the Committee, it is found that it was lent at an interest of $1\frac{1}{4}$ per cent. per annum only. There also appears an item of "Contract for running new main Holborn, £195. 19s. 4d.," and this was found upon investigation to be a payment to another firm of electrical engineers to run electrical wires to the Company's installations. This would seem to be peculiarly work proper to be done by the Company's own workmen instead of employing another firm to do it at a profit. In conference with the Directors, their explanation of this matter was that they thought it would be advisable, and was the best course in their opinion. As to the statement in the Directors' notice that the item of £25,190 for goodwill and patent rights should be no longer maintained at that figure, and their intention of reducing it to £527, in conference with the Directors, the following were the reasons given by them for this proposed reduction :—That the patents stood at cost price, and had only six or seven years to run, and that they were advised that if they earned profits it would not be advisable to pay dividends upon that amount. There was no data furnished for the reduction to £527, which appears to have been a purely arbitrary sum, and is given by the Directors as their opinion of value without supplying any basis of its calculation. In proposing this enormous reduction (as a matter of principle, and apart altogether from the amount of it), the Directors have merely considered the fact that the patents are running out, and have entirely ignored the goodwill, overlooking that under good management the value of the goodwill of the business should increase in at least *the amount* of the diminution of the value of the patents. It is obvious that the mere goodwill of a business which is said to earn £5,000 per annum from its installations must be worth immensely more than £527. As to the general business of the Company, under the existing system of management it has not been, and it is not possible that it should be, worked with either efficiency or economy. There is no proper system of check or control of stores issued. The books of the Company are not properly kept, and some of them are even now not posted since January last. The Company have obtained many orders for lighting and have left them unexecuted for several months, in some cases actually going to the expense of running the wires without fixing any lamps. There is no reserve of power at the Stanhope-street Installation for any further business, and at Whetstone Park Installation there is no reserve boiler power, and the whole installation is at the risk of a breakdown from the leakage of a single tube. The sum of £4,769. 7s. 5d. has been realised from the sale of Consols by the Directors, and spent by them during the period in which two of the three Directors were disqualified, and their office vacant, without any improvement in the financial position of the Company, and but for the repayment by them since the last meeting of £200, which they had improperly paid themselves for directors' fees, the Company would have had absolutely no money at the bank at the commencement of this investigation. In the now existing condition of the Company it is, of course, necessary that capital should be obtained to enable it to carry on its business properly or at all. The business, if properly managed, should be a successful and profitable one, as the system of lighting is exceedingly popular with all its customers, the number of whom might be almost indefinitely increased. It is regretted that it has not been possible to submit this report to the shareholders at an earlier date, but the committee have not been facilitated by the Directors or the Secretary in their investigation, and from the 29th March to the 4th April instant the offices of the Company were closed, the Secretary absent, and the books locked up, although he had been distinctly informed that the committee desired to have access to them, and continue the investigation during that period. During that absence of the Secretary and Manager one of the installations had to discontinue its lighting of a public-house at 9:30 in the evening, because at the Stanhope-street Factory there were no coals. The attitude of the Directors in regard to the investigation will appear from the following letters :—

68, Cornwall-gardens, Queen's Gate, S.W., March, 1888.

Dear Sir,—I have been expecting to hear from the committee appointed at the "Pilsen" meeting on the 13th instant to confer with my late colleagues, but hitherto I have received no communication from them. Mr. Trentham informs me that you wish to take stock. At present I do not see the utility of this, or that it comes within the scope of the resolution, but, of course, I shall be glad to hear what the committee has to say on this subject.

For this or other purposes it seems to be in accordance with the resolution that there should be a meeting of the committee with myself and my late colleagues, and upon hearing from you I will either convene such a meeting myself, or will endeavour to arrange to meet the committee with my colleagues.

I do not read the wishes of the shareholders, as expressed by the resolution, to be that you or the committee should take any action at the factory, or at any of the installations, except in conference with me.

I take the opportunity of informing you that the intervention of the Easter holidays, and the convenience of the shareholders, seemed to me to make it desirable to hold the meeting to elect Directors on the same day as the adjourned meeting (13th April). Notices will be shortly issued accordingly.

Please communicate this letter to the committee.—Yours faithfully,

(Signed) Rawson W. Rawson,

Chairman of the Pilsen-Joel and General Electric Lighting Company, Limited.

St. Stephen's-chambers, Telegraph-street, E.C.,
27th March, 1888.

"Pilsen" and "Joel" Company.

Dear Sir,—I beg to acknowledge the receipt of your letter dated 23rd, but delivered on the 25th inst.

Neither I nor my colleagues on the committee whom I have been able to consult can accept your view as to the very limited scope of the investigation which you suggest, but, of course, when we are in a position to do so usefully by means of the investigation we are making, we shall wish for an opportunity of conferring with yourself and the late Directors, and will ask you to be so good as to arrange it. I cannot but think it was a strong proceeding to delay the meeting for election of Directors, when the Secretary had been directed by the shareholders to send out notices *forthwith*.—Yours faithfully,

(Signed) James Fyfe

Sir Rawson W. Rawson, K.C.M.G., &c.

EASTERN EXTENSION TELEGRAPH COMPANY.

The report of the Eastern Extension, Australasia, and China Telegraph Company, Limited, for the half-year ended December 31 states that the gross receipts, inclusive of Government subsidies, amounted to £232,660, against £216,956. The working and other expenses, including £22,730 for cost of repairs to cables and expenses of ships, absorbed £69,570, against £80,066. After deducting income tax, interest on debentures, and contributions to sinking funds, and bringing forward £35,162, there is an available balance of £153,051. A quarterly interim dividend of $1\frac{1}{4}$ per cent. has been paid, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 3s. per share, or $1\frac{1}{2}$ per cent., making a total distribution of $6\frac{1}{2}$ per cent. for 1887. The balance of £53,051 has been carried to the general reserve fund, which

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	4¼
15 Feb.	10/0	Anglo-American	100	38½
15 Feb.	20/0	— Pref.	100	65
12 Feb., 85...	5/0	— Def.	100	13¾
28 Mar.	3/0	Brazilian Submarine.........	10	12⅛
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	12¼
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	8⅞
12 April	2/6	Eastern	10	11⅝
12 April	3/0	— 6% Pref.	10	14¾x
1 Feb.	5%	— 5%, 1899	100	110
28 Oct.	4%	— 4% Deb. Stock	100	108¾
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	13
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	101½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5 1-16
12 April	3/0	— 6% Pref.	10	14x
3 Jan.	5/0	Great Northern...............	10	15

Dividend.		Name.	Paid.	Price. Wednesday
1 Mar	5%	Gt. Northern 5% Deb., '83.	100	109
28 July	10/0	India Rubber, G. P. & Tel.	10	17¾
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5¾
16 Mar.	5%	Maxim Weston	1	⅛
15 May	5%	Oriental Telephone	11	7/16
14 Oct.	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2½
15 Feb.	15½%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
14 July	12/0	Telegraph Construction ...	12	40
3 Jan.	6/0	— 6%, 1889	100	107
30 Nov.	5/0	United Telephone	5	14¾
......	...	West African	10	5
1 Mar.	5%	— 5% Debs.	100	92½
29 Dec.........	6/0	West Coast of America ...	10	5¾
31 Dec.	8%	— 8% Debs.	100	117
14 Oct.	3/9	Western and Brazilian......	15	10½
14 Oct.	3/9	— Preferred	7½	6¾
......	...	— Deferred..................	7½	3¾
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	10¾
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. April 9 ...	£4,503	...
Cuba Submarine	M. of Mar. ...	3,800	+ £73
Direct Spanish.....................	M. of Feb. ...	1,900	+ 37
— United States	None	Published.	...
Eastern...............................	M of Mar. ...	54,376	+ 4,579
Eastern Extension	M. of Mar. ...	£39,670	+ £1,493
Great Northern	M. of Mar. ...	22,000	...
Submarine	None	Published.	
West Coast of America	M. of Mar. ...	4,175	...
Western and Brazilian	W. April 9 ...	3,554	...
West India and Panama	F. March 31 ...	3,703	+ 273

Abbreviations: W., week; F., fortnight; M., month.

NEW ELECTRICAL COMPANIES.

Electric Date and Time Stamp Company, Limited.—Registered by M'Diarmid and Teather, 5, Newman's-court, Cornhill, London, E.C. Capital £100,000, divided into 100,000 shares of £1 each. Object: To acquire the benefit of an invention of an electro-mechanical dater time stamp, for which provisional protection was obtained under the Patents, Designs, and Trade Marks Act, 1883, on November 16 last, and which is numbered 15,717. The first subscribers are:—

	Shares.
H. Lockwood, law stationer, 93, Chancery-lane	1
T. R. Frolich, gentleman, 32, Princes-road, South Norwood	1
R. C. Dover, tea taster, 155A, Upper Thames-street, London, E.C.	1
J. J. Nolan, gentleman, 19, Lyndhurst-road, London, S.E.	1
E. J. Summers, gentleman, Warwick Villa, Croydon-road, Anerley	1
W. Brown, merchant, 11, Queen Victoria-street, E.C.	1
E. W. Gallagher, music teacher, 43, Camden-grove, Peckham, Surrey	1

The number of Directors shall not be less than three nor more than seven. The first shall be appointed by the subscribers to the memorandum of association. The qualification of a Director shall be the holding of stock or shares in the capital of the Company of the nominal value of £250 each. The remuneration of Directors shall be the sum of £800 per annum, paid out of the funds of the Company, and divided amongst them as they may think fit.

St. James' and Pall Mall Electric Light Company.—This Company has been formed in order to establish a central station for the supply of the electric light to the area of which St. James'-square may be described as a centre, and which includes Pall-mall, St. James'-street, Piccadilly, and Waterloo-place. The prospectus has been advertised during the week, but the lists close before the issue of the technical papers. The prospectus states that a provisional contract has been made with Messrs. Latimer Clark, Muirhead, and Co., of Westminster, for a supply of the necessary plant to establish a first installation of 10,000 lamps, in full working order and with every requisite, at an estimated cost of £18,500, to be erected in portions as required by the Company. The price and the terms of the contract are to be subject to the approval of the Engineer of the Company. The price of the site is £9,500, and a rent-charge of £100 a year for forty-two years. The charge for lights will be made either by contract, at a certain sum *per lamp per annum*, or by meters, which will be tested and certified by professional authorities. The Company will pay nothing for patents, and will pay its own preliminary expenses, which will be the charges actually incurred. The people who have formed the Company and guaranteed the preliminary expenses and the subscription of a portion of the capital, look for their remuneration to the 100 founders' shares of £1 each, which will be taken up by them. The capital is £100,000 in 19,980 ordinary shares of £5 each, and 100 founders' shares of £1 each, and 10,000 of the ordinary shares are now offered for subscription, of which it is stated 3,000 are subscribed by the Directors and their friends. The district it is proposed to light is perhaps one of the best in London for such a purpose, though it should not be forgotten that many of the large hotels, clubs, and houses in the district are already provided with the electric light.

Southampton Electric Light and Power Company, Limited.—Registered by Richard Jordan, 120, Chancery-lane, W.C. Capital £30,000, divided into 4,000 preferred shares of £5 each, and 2,000 ordinary shares of £5 each. Object: To carry on the business of electricians, mechanical engineers and manufacturers, and workers and dealers in electricity, motive power and light, and generally any business in which the application of electricity, or any like power, is, or may be, useful, convenient or ornamental, or any other business of a like nature; to carry on the business of manufacturers of, and dealers in, machines, lamps, lanterns, safety lamps, and other appliances for supplying light and power by means of electricity. The first subscribers are:—

	Shares.
J. H. Aldridge, M.D., 13, Anglesea-place, Southampton	1
J. Bishop, boot manufacturer, Grosvenor-square, Southampton......	1
E. G. Rose, brewer, Westwood, Southampton	1
J. Appleford, merchant, Millbrook, Southampton	1
J. G. C. E. Vanore, Lloyd's agent, Southampton.........................	1
J. Miller, outfitter, 177, High-street, Southampton	1
E. Brown, butcher, 17, Above-bar, Southampton........................	1
R. Allen, 183, High-street, Southampton	1

There shall not be less than three, nor more than twelve Directors. The first shall be appointed by the subscribers to the memorandum of association. The qualification of a Director shall be the holding in his own right of shares of the nominal value of at least £250. The remuneration to the Directors shall be fixed by the Company in general meeting.

of nickel slowly increases with the temperature from 0deg. to 225deg. cent., and more rapidly from the latter temperature up to 365. From this point the resistance augments more slowly as the temperature is increased. 2. That the temperatures at which the variation in the rate of the increase of resistance occurs are the same as those at which irregularities in the thermo-electric properties of the metal are observed.

The Electric Light in Sweden.—The experimental installations carried out at Stockholm have been so successful that the same system—that of Messrs. Ganz and Co., of Budapest—will probably be adopted in a large number of new installations. The machines already working in this capital are located at the gas works, and the total length of the distributing mains is 2,000 metres. The conducting wire is of copper, 4 millimetres in diameter, and is supported on posts. Several restaurants are lighted by incandescence lamps, and the entrance to the opera by several arc lights. The town of Falun is shortly to be lighted by 50 arc lamps of 1,200 c.p., and 300 incandescence lamps.

Arc Carbons.—The manufacture of carbons for arc lighting has in Austria become an industry of some importance. The Hardtmuth factory, at Dobling, produces about 3,500 metres of carbon rod per diem. The processes of manufacture have recently been improved in several particulars, the carbons being of greater density and more homogeneous. The improvements apply more particularly to cored carbons. The rod, formed of plastic material, passes from the press in the usual manner in the form of a tube. After drying and baking, the carbon tubes are saturated with a hydro-carbon, which fills the pores; and after a second baking the core material is introduced at a certain pressure.

A " New " Lamp Maker.—A well-known electrician told us a pretty good story the other day, the truth of which he vouches for. He, in company with another gentleman, was recently visiting a place where dynamos were manufactured. The superintendent, who was also, we believe, the electrician of the establishment, showed them through the factory, explaining the principle of the machine made by his company, and talking on various electrical subjects. In the course of the conversation Mr. Superintendent was asked whose lamp they were using. He replied he was not quite sure on that point, but (examining the lamp) thought it must be Mr. Volt's, as his name was on the lamp!

Electricity Ubiquitous.—The Electric Club of New York is replete with every electrical appliance. Thus, on approaching the door, instead of using a bell-pull, the visitor, by pressing his foot on a metal plate, rings an electric bell, and the door is unlocked by electricity and opens at once. The house is lighted by incandescent lamps, of which there are 350. In the kitchen is an electric gridiron, which broils the meat by use of electricity from the lighting apparatus passing through and heating the wires of the gridiron. The boots are blacked and polished with brushes worked by the same power, the clocks wound, the lock on the safe opened, and even the piano played by electricity.

The Installation at Saint-Etienne.—Quite recently unexpected difficulties have arisen in connection with the working of the central station in this town, a description of which was given in our last issue. It is stated that in those portions of the distributing system where copper bars enclosed in iron tubes, filled with an insulating compound, are employed, a large number of lamps can no longer be worked, and it has been necessary to have recourse to gas. It is evident that the insulation between the direct and return mains has broken down. According to the *Bulletin International de Electricité*, the Saint-Etienne Company intend to take proceedings against the Edison Continental Company, under whose advice the system of laying which has occasioned the breakdown was adopted.

The Bell Telephone Case.—The *Electrical World* says: As to the generally prevailing impression that there is more or less probability of a rehearing of the Bell telephone cases by the United States Supreme Court, Justice Miller says that such action is extremely improbable. In the twenty-five years he has been on the Supreme Bench there have been but ten rehearings. When, as in the telephone case, the bench is nearly equally divided, every point bearing on the case in the most remote degree is thoroughly canvassed, and nothing in any way bearing on the case is passed over. But when the bench is unanimous, or nearly so, a decision may perhaps be reached without so thorough a canvass of all phases of the subject, and some minor point may be overlooked and a rehearing granted, but this is a very rare circumstance.

Monkeys on Telegraph Wires.—A formidable antagonist to telegraph construction in Mexico is found in the monkey tribe which inhabits the jungles and chaparral of Tabasco. Literally "the woods are full of them." Their favourite diversion when not in quest of food is to betake themselves to the telegraph lines for gymnastic exercises, and linemen assert that often 100 able-bodied moneys have been seen swinging on the wire, festooned, monkey fashion, by looping their tails. The continuous vibrations of these forest gymnasts start the iron nail used on the cross arms, and these often come down, bringing the wire with them. And it is not a safe matter to undertake to disperse these robust monkeys, who play the dickens with telegraph lines in the sparsely inhabited State of Tabasco. Linemen have found that on shooting a monkey swinging on the wire they have been pursued by a whole regiment of monkeys.

The Writing Telegraph.—In the House of Commons on Monday Mr. M'Ewan asked the Postmaster-General whether it was true that, after six months' consideration, the Post Office authorities had refused to grant a license to the proprietors of the Writing Telegraph to use their system under the same conditions as the various telephone companies use their systems; and whether, if it be true, this was in accordance with the usage in respect to other companies desiring to use telegraph systems. Sir H. Maxwell: I am requested by my right hon. friend to say, in reply to the hon. member, that it is the fact that, after due consideration, he has refused to grant a license to the proprietors of the Writing Telegraph. He thinks it preferable that, if there is a substantial demand for the establishment of exchanges to be worked by that instrument, they should be in the hands of the Post Office, the instruments being supplied by the proprietors on terms to be arranged.

St. James'.—At a meeting of the St. James' Vestry, last week, Mr. John Bonthron presiding, it was agreed to support the application of the St. James' and Pall Mall Electric Lighting Company to the Board of Trade for a licence. The draft licence follows the lines of the South Metropolitan Electric Lighting order, but

of the theatre in front of the stage are lighted by 180 20-c.p. lamps; whilst the stage is supplied with 1,162 lamps, of which 550 are in ordinary use, and 612, tinted with various colours, serve to obtain different effects of light. The lighting and the regulation of all these lamps are controlled by a commutator of special make. About 630 cut-outs are distributed in the circuits so as to obviate any accident.

Commission of Sewers.—Last week a special meeting of the Commission of Sewers was held at the Guildhall to consider a letter from the Remembrancer relative to the application of the South Metropolitan Electric Light Company to the Board of Trade for a provisional order. Mr. W. H. Pannell presided, and said the Remembrancer would read a letter from the Parliamentary agents to the South Metropolitan Electric Light Company, enclosing copy of a letter from the Board of Trade stating that it was proposed to consider objections to the license at 11 o'clock on Friday, when the representatives of the Commission of Sewers were requested to attend. The chairman said that on the last occasion a resolution was passed by the Commission instructing the Remembrancer to lodge objections to several Bills in Parliament, this being one. The Remembrancer did lodge objections accordingly. The area laid down by the company included part of the area called Blackfriars site, with regard to which the Commissioners were at the time in negotiation with the Brush Company. This was one of the choicest sites in the whole metropolis for electric light, comprising all the newspaper offices. Since then the Commission had declined to go further with the Brush contract; therefore, an important factor in their application was removed. They had already four applications before the Commission or its committees from four electric lighting companies, with offers to light the whole or a portion of the City.

The Central Station at Rome.—Important extensions of electric lighting are taking place in this city. Amongst the most recent installations carried out by the Gas Company are those at the Quirinal *piazza*, the Quirino Theatre, the Metastasio Theatre, the Café des Variétés, and the establishments of Messrs. Bocconi and Messrs. Pinzi and Bianchelli. The piazza above-mentioned, the lighting of which has given great satisfaction, contains nine arc lamps of 1,000 c.p., worked by transformers located at one of the angles of the palace of the Council, and connected to the central station by Siemens' cables. The lighting of the Quirino Theatre comprises one exterior arc lamp and 200 incandescence lamps in the interior of the building. That of the Bocconi establishment includes one central arc lamp of 2,000 candles, 86 arc lamps of 1,000 candles, and 200 16-c.p. Edison incandescent lamps. The latter are included in a special circuit, worked by an Edison dynamo located in the basement, and driven by an Otto gas engine. The arc lamps are arranged in ten distinct circuits, corresponding to the same number of transformers, worked from the central station. This installation has produced a great effect, being much admired by the public. No description of meter or counter is used by the company, the consumption being paid for according to the number of lamp-hours, which is noted, and jointly verified by the company and the consumer. This system will no doubt be found very disadvantageous when a number of small consumers have to be supplied; but it would appear that a simple and cheap meter, giving accurate indications which can be read by the consumer himself, is a desideratum which is not yet forthcoming.

Gas Companies and Electric Lighting.—In America, the gas companies are closely watching the progress of the electric light, and from time to time, at meetings, papers are read—the moral being that it will be well if the gas companies take up the work themselves. The men interested in the gas interests there are much more open to conviction than men similarly situated here, to judge from the technical journals. We are fairly consistent readers of the *Journal of Gas Lighting*, for example, and for a long time past this paper has devoted one article per week to the consideration of electric lighting. The humours of *Punch* are not in it when compared with the humours of these articles. Pope, the greatest exponent of poetic satire and rancour, would have paled before the prose writer of the *Journal*. Nothing good can possibly come out of electricity—hence, week by week, we are amused at the extraordinary efforts made to find out some weak spot. The writer quotes largely from the *Electrical Review*; but is so utterly unable to understand the meaning of what he quotes, that his lucubrations, instead of convincing, end simply in being amusing. The same paper, however, occasionally has the courage to quote from American contemporaries, as for example, in its issue of April 24, when it gives a paper by Mr. Day, read at the annual meeting of the Ohio Gas-Light Association. The conclusion of this paper is as follows:—"It would seem from the figures here given that gas companies are much more favourably situated for furnishing both arc and incandescent lights, or electric currents, than anybody else; and that they should pursue the policy of fortifying themselves in their present positions by obtaining authority to do so if necessary. Keep an eye on the public pulse, and, if they will have it, give it them. By so doing they would make a powerful ally of what might, under some circumstances, be a formidable foe. Failure to occupy a field of action in advance of others sometimes results in disaster." Are not these words of wisdom to our own gas companies?

Anglos.—The following letter to the *Financial News* shows that there is a growing dissatisfaction with the directorship of the "Mutual !!! Society." We have strong reasons to believe that the directors will not forego one ounce of their pound of flesh, nor one stiver of their fees. A director may with advantage to himself be a director in a dozen companies, but we doubt if it is so advantageous to the shareholders:—"The Anglo-American Telegraph Company is again paying a fractional dividend, while the shares are drooping in value, and nothing is heard of peace negotiations between the rival companies. Some months ago you most conclusively pointed out in your paper the advantages that would follow on a settlement of the cable war, and the restoration of a fair and just scale of rates, and with your able advocacy I still hope to see the object attained. It is admitted on all hands that the sixpence rate is too low to admit of anything more than the ghost of a profit on the amount of capital invested, while a fifteen or twenty pence rate would be fairly remunerative to the shareholders, would not be considered exorbitant by the public, and would be far below the rate charged a few years ago. Then, why should this insane and unbusinesslike competition and war of rates continue? Six months ago the Commercial Company were willing to make the rate twenty pence a word if the other companies would follow suit; but no agreement was come to. If the directors of the Anglo Company, in keeping to the sixpence rate, are inspired by a feeling of universal benevolence and philanthropy, then they

should put themselves into the same boat with the shareholders, and abjure their fees; but if they wish to make their company a financial success, while at the same time conferring a benefit on mankind, they should renounce their policy of masterly (?) inactivity, and endeavour strenuously to effect an equitable adjustment of rates. Should they fail in this, after honest and straightforward attempts at reconciliation, then the shareholders will know where to lay the blame; but from the previous action of the Commercial Company it is evident that a twenty pence rate would be willingly agreed to by them."

Non-Magnetic Watches.—Our American cousins know how to advertise, and are not afraid of the returns from the amount thus expended being unsatisfactory. The Waltham Watch Company is of a different calibre to the Waterbury Company, and both companies do a large business in England. Why should this be? No doubt the answer is that English firms take years to consider the advisability of providing what is required, while the Americans try to anticipate the requirements. Viewing some installations the other evening, a friend said, "Look out for your watch. Mine won't hurt: it is a special Waltham." The reply was, "Neither will mine, for I havn't one." An article in the *Scientific American*, of April 14th, on this subject contains the following sentences:—"People carrying valuable watches, or depending upon pocket timepieces of any kind, seldom properly appreciate the risks they run of destroying their accuracy and rendering them totally unreliable by going anywhere near electrical machinery, of which the use is now becoming so general. From this one cause probably proceeds more of the 'crookedness' in the watches now made than can be attributed to any other one source, and it is a difficulty which watchmakers have been earnestly striving to meet by the use of anti-magnetic shields, composition balance wheels, &c. What seems to have been a successful effort in this direction, by the American Waltham Watch Company, was recently made the subject of an interesting test. The company, after a long series of experiments, has perfected an alloy for use in their balance wheel, escapement, and hair-spring, which is apparently non-magnetisable, and not affected by proximity to the strongest dynamos. One of their regular watches, provided with these parts made of this alloy, was subjected for fifteen minutes to the influence of Major King's great cannon magnet at Willetts Point, N.Y., without at all affecting the time of the watch. The watch was held in close proximity to the muzzle of one of the guns, forming one pole of the magnet, where the magnetic effect was strongest. Its main-spring and other portions became so highly charged as to retain their magnetism for several days afterwards; but the hair-spring, balance, and escapement were so totally unaffected, that the rate of the watch, as noted by an astronomical clock before, during, and after the experiment, showed no change whatever. The use of dynamos is now becoming so general that one never knows when he may be in close proximity to one, either in travelling on the cars, visiting places of amusement, inspecting goods in stores or warehouse, or in manufacturing establishments of any kind. Their influence is not interfered with by the interposition of walls or partitions, and the hitherto trusted timepiece needs but to be brought sufficiently near to be rendered worthless, or have its value seriously impaired, while the owner may be in total ignorance of the cause. The result now obtained by the Waltham Company is said to be secured without any sacrifice of the qualities desired in the parts of the watch made of their improved alloy, the latter itself being slightly different in the different parts."

Organ-Blowing by Electricity.—A new departure has been made at St. John's Church, Taunton, where the first successful attempt has been made to solve the problem of organ-blowing by electricity. The organ has 36 stops, and the blowing is so quietly effected—without the vibration which even the steadiest manual blowing imparts, and without the tension on the bellows which blowing by gas engine involves—that the pleasure of playing upon so excellent an instrument is greatly enhanced. The organist has at any time of the day or night simply to take his seat at the manuals, and turning on a switch—as he would turn on a water-tap—can commence playing at once. This switch brings the whole arrangement under his complete control; it is affixed to the front of the organ just above the stops on the right hand of the manuals, and communicates through a series of carbons—which bring the current to a very low intensity, and render the appliances perfectly safe to handle—with the motor in the tower some 45ft. above. The motor is of nominally half-horse power, but will develop about double that power. It weighs 42lb., and occupies about ten square inches of space: the armatures change the polarity of the electro-magnets surrounding them, and thus cause the revolutions of a wheel about 3in. in diameter—about 1,600 revolutions per minute being attainable. The motor, which is by Messrs. Immisch, was supplied, and the electric connections made, by the Electric Lighting Company, under the superintendence of the electrician-in-charge, Mr. Hooker, and it is worked by 30 large-sized accumulators at the central depot, rather more than a quarter of a mile distant. The motor and machinery attached thereto are suspended on beams built into the tower, so as to avoid the possibility of any vibration. The small wheel of the motor is attached by a half-inch rope to a fly-wheel 4ft. in diameter, an ingenious arrangement by a weighted pulley compensating for changes in the temperature. This portion of the work has been carried out by Messrs. Allen, engineers, Taunton, and the remainder by Mr. Minns, organ builder. The fly-wheel operates a double feeder, 4ft. by 2ft., which, when working at full speed, will make 90 strokes and deliver about a million cubic inches of air per minute. Close by is a reservoir, with powerful concussion bellows, and this communicates, by means of a trunk 40ft. long, and 22in. by 5in., with the large wind chest of the organ; this trunk is carefully insulated and ends in a small chamber with a roller valve, acting automatically, which prevents too great a pressure of wind being forced into the wind chest. As soon as the wind chest is full, the current is broken by an automatic switch and the motor stops; but when the reservoir has lost about an inch of its distension, the switch again completes the current and a few revolutions of the motor restore the equilibrium—a piece of asbestos preserves the woodwork from injury by the flash arising from the breaking of the current. The organist is provided with two switches, one of which is of low intensity and allows a sufficient current for ordinary service playing, while the second supplies the additional power necessary in case of a prolonged loud voluntary. On the whole the installation is a most gratifying success, and Taunton may be congratulated on leading the way to another application of the uses of electricity.

THE USE OF ELECTRICITY FOR THEATRE LIGHTING.*

BY E. GEORGE TIDD.

Before entering upon the subject of the various systems and their working now in use in our London theatres (for I shall confine myself exclusively to London), I wish to point out the great advantages which accrue, both to the public and to the management, both to those before and behind the curtain, by the use of electric light in theatres.

Firstly, then, the danger of fire would be—*must be*—very materially decreased by the use of the electric light.

Almost all our great theatre fires, of which we have heard of so many lately, have had their origin behind the curtain, in the "flies," where the fearfully inflammable material of which the scenery is composed is ever in close proximity to, comparatively speaking, unprotected gas-jets, and which, perhaps, by the merest chance, a puff of wind, or a slight flaw in the working of the scenic machinery, may catch some portion of the canvas, thickly coated with oil and paint, and in the short space of a few minutes the whole building may be in flames. Now, were these fatal gas-jets replaced by electric lamps, what matter if the wind, or an accident in the machinery, or any other unforeseen cause bring them in close contact with the scenery—there would be no risk of fire. When one thinks of the frightful calamity which only a few months ago happened at Exeter, by the burning of the theatre in that town, caused by just such an accident in the flies, of the awful loss of life which attended it, and under the most horrible and distressing circumstances, one cannot help feeling that those who have the safe keeping of the theatre-going public in their hands are wanting in their duty by not ordering the compulsory use of electric light in all theatres, by which they would enjoy almost a complete immunity from fire; and I am glad to hear it reported that the new Metropolitan Theatre Bill will contain a clause making the use of the electric light compulsory in our theatres.

It is interesting to note that while those in authority have caused hundreds of pounds to be spent to insure the safe exit of an audience in case of fire, they have not yet taken any steps whereby the chances of that event might be lessened. It is, of course, a very wise thing to take precautions in case of fire, but would it not be much better to take precautions against the risk of the fire itself? By compelling managers to use the electric light, and that light only, behind the curtain in their theatres, the chances of fire would be reduced almost to a minimum.

Another great boon which the electric light confers upon the public, and which adds materially to its comfort, is the absence of that excessive heat which is always felt in any building where a quantity of gas is burnt; again, the nauseating smell caused by stale burnt-out gas is entirely absent. Undoubtedly, to a great extent, the heat in theatres—and there must always be heat where a quantity of people are massed together—is caused by the want, and in some cases, I believe, by the almost entire absence of proper ventilation. Of course, it is a difficult matter to ventilate a theatre to perfection, but is not this all the more reason for having electric light, by which the imperfect system of ventilation would not be so much felt? Go to the Criterion Theatre, for instance—which, bear in mind, is totally underground, being under the restaurant, and the roof of the theatre being on about a level with the road—and there, by a fair system of ventilation, combined with the use of the electric light and *entire* absence of gas, the performance is carried on in an atmosphere of purity and, as compared with other theatres, of coolness, to the comfort of all concerned.

Some have adduced the argument that the illusionary effects produced by gas and limelight would be unobtainable with the electric light. This is quite a mistake; several managers to whom I have spoken say that they much prefer the electric light, and we must surely agree with them when we see it adopted at the Gaiety, where, perhaps, more than at any other theatre, these effects are required. In fact, I believe that far greater effects could be obtained by the use of the electric light; for whereas gas can only be *turned down low*, the electric light can be completely extinguished at will, and can be as instantly relit, without the least trouble. *Apropos* of this subject, an objection that managers advanced, and that some still put forward, against the electric light, is that it cannot be partially raised and lowered at will; this, as you all know, is quite an erroneous idea. And while on the subject of objections of managers, we may just give a word as to the arguments of the cost of electric lighting. Now, for instance, the Alhambra has just been redecorated at a cost of £10,000, and this outlay will last three times as long as it would have done under the old system of gas, thereby fully compensating for the original outlay on the electric light installation.

The Lighting of a Theatre by Electricity varies in several important points from an ordinary installation, and there are special details which require careful consideration. First, to take the requirements of the auditorium. The lamps in the passages, cloak-rooms, &c., are always required to be alight, so they must be on a separate circuit to themselves. The light in the auditorium itself is required down during the performance, and up between the acts. In some theatres *all* the lights are *lowered*, and in others most are entirely extinguished, while a few are left at full candle-power. This, of course, requires the lamps to be on two circuits.

Here I will point out a precaution that I think should always be taken—namely, having in the auditorium two complete circuits, so that in case of a breakdown or fault in one circuit the theatre will not be plunged into darkness, and there would be no risk of panic. To lower the light, all we have to do is to lower the difference of potential between the terminals of the lamp. This is done practically in two ways: (1) by inserting a resistance in the circuit; (2) where accumulators form part of the circuit, by cutting out a certain number. In the first case a certain amount of energy is always being used, only a part of which is doing useful work, the other part being employed in overcoming the resistance. In the second case, only the amount of energy which is expended in useful work is drawn from the cells; an objection to this is that the cells are discharged unequally, so that in fully charging the cell with the least charge a certain amount of energy will be wasted in over-charging the more fully-charged cells. By joining up the various circuits to the cells according to their use, position, &c., the discharge can be rendered more uniform. Another great objection to this method is that when the number of cells in circuit is altered, either the circuit is broken or the additional cells are short-circuited. I believe Profs. Ayrton and Perry have devised a switch to obviate this by putting a cell on to a resistance.

To work on a strictly efficient basis, it would be more economical, when half the light is required, to switch off half the lamps, as the efficiency is much higher if the lamps are running at a high candle-power. Thinking that perhaps it might be of interest to some here, I plotted a curve of candle-power and efficiency with tests made with a nominal 20 candle-power lamp. In speaking of the efficiency, I mean the inverse of the true efficiency. If I took the true efficiency or candle-power per watt, the result would be a fractional quantity. You see from the curve that the efficiency keeps very low until 5 or 6 candle-power is reached.

Now to consider the most important part of a theatre installation—viz., *the stage lighting*. The principal lights used are as follows:—

(1) *Floats or Footlights.*—Generally two rows for white and green lamps, and where great effects are required a row of red lamps is added. These three sets are generally all put in the same circuit with simply make and break switches.

(2) *Proscenium Lights.*—Two sets of these are required, one on either side of the proscenium; they are often on hinged boards, so as to turn to any angle.

(3) *Battens or Top Lights.*—There are never less than three rows of battens, and generally more. Each row must be able to be separately regulated.

(4) *Wing Ladders or Side Lights.*—There are two or more

* Paper read at the Students' Meeting of the Society of Telegraph-Engineers on Friday, April 20th.

pairs of these, but they are never permanent fixtures. They generally hang on rods from the roof, so as to be readily brought forward or backward, and turned to any angle. Special connections are required on account of their often having to be entirely removed.

All the lights on the stage must be arranged for raising and lowering; whether they are raised and lowered all together, or each set separately, depends upon the theatre and the style of play produced there.

There are now in London ten theatres and music-halls where the electric light is used, viz.—Alhambra, Criterion, Empire, Gaiety, Haymarket, Oxford, Pavilion, Prince of Wales's, Savoy, Terry's, and one other, viz., Adelphi, where the light is now being installed. There are three new theatres now being built in London, all of which are to be entirely lighted by the electric light; and it is a fact worthy of note that since 1881 no theatre has been built (with the exception of the Avenue) in which the electric light has not been used.

I now propose to give a short outline of the various installations which I have been permitted to inspect. First, I shall take the Criterion Theatre, which is, I think, one of the most satisfactory I have seen, being an installation complete in itself, having the electrical power under its own control, and not being dependent upon leads from any other source. The installation was put up by the Edison Company at the beginning of 1884, and has continued running from that time without a single hitch of any kind. No gas is used in the theatre at all. The plant consists of three old type Edison machines driven by 100-h.p. engine; the engine house, which is a little distance from the theatre, also contains two Edison-Hopkinson machines, driven by a similar engine, and used for lighting the restaurant. The dynamos are connected in arc, being attached to a special plug switch-board. Arrangements are made so that in the event of the engine breaking down all the load would be thrown on to the restaurant machinery. This would, of course, bring all the lamps down, but there are enough that could be switched out in the restaurant by switches in the dynamo room to enable the performance at the theatre to proceed without interruption. The engineer has to keep the difference of potential up to 150 volts. A regulating switch-board is placed in one of the passages leading off the stage. There are ten circuits, which include resistances, which are adjusted by sliding contacts. The first circuit supplies the foot-lights (of which there are two rows, a white and a green), of 28 16-c.p. lamps per row. Each circuit has its own switch and cut-out, but both are regulated by the same resistance. The second circuit supplies the dome, where there are 59 10-c.p. lamps. The next supplies the lamps round the circles in the auditorium. The next supplies the wing ladders, of which there are four sets, having a total of 80 lamps. The other six circuits supply the battens, each batten having a separate resistance, so that it can be regulated apart from the others. There are forty 16-c.p. lamps in each. There are, besides these, two more circuits regulated by the two switches at the end of the diagram, one of which supplies the dressing rooms, passages, &c., and the other supplies some lamps which are placed inside reflectors, let into the ceiling of the gallerys, so as to give a downward light on to the programmes; these lamps are left at full candle-power all through the performance. Each circuit is supplied with a pilot lamp and cut-out. There are about 700 lamps in the whole installation. The resistances are under the stage in a large slate case, which is well ventilated. All the leads, &c., are attached to the back of the switch-board, there being a narrow passage behind it to effect this. The wing ladders have flexible wires attached to them, which are passed through holes in the stage, and fastened to terminals underneath.

I will now take Terry's Theatre, which is one of the most recent ones. The fittings and wiring were done by Messrs. Verity, of Regent-street. The current is supplied from the Grosvenor Gallery. At first the supply was anything but regular, but it has lately been better. I shall not renew the question of direct *v.* alternating currents, but shall let facts speak for themselves. This theatre is supplied with gas, which is always kept at a blue flame. There are two Ferranti converters, which are placed in a fireproof place near the roof. The switch-board is placed on one side of the stage, and consists of ten switches and fuses. The switches marked "front," "dressing rooms," "auditorium," and "wings" worked straight through the lamps; the other six work through adjustable resistances. The resistances are contained in a box measuring only about 18in. by 12in. by 8in., and it is placed on one side of the switch-board; each set consists of twelve carbon rods, the tops and bottoms being alternately connected by brass strips. Along the top row of strips a brass slide works, so as to include 2, 4, 6, 8, 10, or 12 of the carbon rods in circuit. With all twelve of them in circuit there is a barely visible glow in the lamps.

The total number of lamps is about 400, and they are distributed as follows:—30 8-c.p. lamps in a circle round the dome. There are no lamps round the various tiers, all being placed at the back. There are nine round the pit, thirteen round the dress circle, eight round the upper boxes, and sixteen round the gallery. The lamps on the stage are as follows:—Float 21 16-c.p. lamps, two rows battens of 30 each, one row battens of 22 lamps, two proscenium lights of eight each, and 96 lamps distributed over the wing ladders. In all the passages a lampholder and gas-bracket are combined. The connections for the wing ladders consist of a plug fitting between two contacts, which are fixed to a slate base, the latter being fastened to one of the beams under the stage.

I will next take the Oxford Music Hall, which is fitted up very similarly to Terry's, having been done by Messrs. Verity, and the current being supplied from the Grosvenor Gallery. The installation has only just had its trial run, so is hardly in proper working order yet. The wiring has all been done in a very perfect manner, and I should think is as near the fire-office regulations as possible. Every bracket has a cut-out on each side of it. The switch-board is placed just off the stage, and consists of 12 switches, and in the centre a circular slide for the resistance. All the stage lights take up 7 of the switches, and they all work through the same resistance, so that they can only be raised and lowered together. One of the remaining switches is for the dressing-rooms, two for the side bars, and the other two for the auditorium; one controls 24 hanging brackets of 3 lamps each, which are switched right off during the performance, and the other controls 6 brackets of 3 each, which are always left full on. There are four battens of 30 8-c.p. lamps each, two proscenium lights of 10 each, and six wing lights of 10 each. These latter are connected by means of plugs, in a similar manner to those at Terry's, only the slate bases to which the contacts are fixed are placed in an iron box filled with cement. The footlights contain 50 lamps, which are connected to bare wires laid in grooved slate, and covered up with Berry's fireproof cement. The slate is laid on an ironwork frame, and insulated from it by means of sheet indiarubber. The whole installation contains 530 lamps. The transformer house is in the basement; the current enters at 2,400 volts and leaves at 100 volts.

Now take the Gaiety Theatre, to which I have before referred. There is a complete installation there, consisting of a 16-h.p. compound engine driving two Goolden-Trotter dynamos, but as the plant is placed under the auditorium, where the vibration is felt, it is only used in case of a breakdown at the Grosvenor, from whence the current is obtained to light the theatre. Steam is always kept up during the evening, and during the late burlesque the current was used during the last act to run sixteen 500-c.p. incandescent lamps. The transformer room contains three transformers, two 250-light 100 volt, and one 150 light 50 volt, connected to this distributing switch-board. This consists of four double pole switches and cuts-out, which supply stage No. 1, stage No. 2, auditorium, 50 volt circuit. All the switches are arranged with a double set of contacts, so that the lamps can be instantly switched from the transformers on to the dynamos. At the prompt side of the stage there is another switch-board with five sets of sliding contacts, by which resistance is inserted separately into the four batten circuits of 52 lamps each, and the float of 54 lamps. The total number of lamps in the theatre is 450. The installation was fitted up by Messrs. E. S. Berry and Co., and is still under their management.

Another installation, the stage of which was fitted up by the same firm, is on much the same lines as the foregoing; this

is the Empire Theatre. The current is obtained from the Grosvenor Gallery, although there is a complete set of Elwell-Parker plant there, which had to be stopped on account of complaints about the noise. There are 12 sets of wing ladders, each containing 15 lamps, one set of floats containing 66 lamps, two proscenium lights, each containing 25 lamps, and six battens of 40 lamps each. All the lamps are governed from a switch-board of the same type as the Gaiety. There are 536 lamps on the stage, and about 500 in the auditorium, making a total of 1,036 lamps. The noticeable thing about this installation is the artistic way in which the lamps are arranged in the auditorium. In front of the gallery there are 18 brackets of two lamps each, hanging over the second circle there are 18 brackets of three lamps each, in front of this there are six brackets of four lamps each. and between them are placed five brackets, each containing three gas burners, which are kept alight. In front of the dress circle there is a close row of single lamps. The dome contains eighteen lamps, besides gas-jets.

Now, to take the Savoy Theatre, which, if taken in order of perfection, ought to rank first, as it was not only the first to be lit, but it contains more lamps than any other theatre. The installation was first used on 10th October, 1881, and was put up and is still under the charge of Messrs. Siemens Brothers, having worked since the beginning thoroughly satisfactory. The stage is lighted by 715 lamps, and there are 601 blue ones, which are used in the night scene of "Pinafore." The lamps are nearly all on a shunt-wound dynamo, and they are regulated by inserting resistance in the field-magnets, a very much more efficient arrangement than that generally employed, the disadvantage being that all the lamps on the dynamo are simultaneously lowered. The battens are made entirely of incombustible material. The wing ladders terminate in triple plugs, which are inserted into contact pieces on the stage. The auditorium is lighted by three branch brackets arranged round the tiers, containing, in all, 150 lamps, the corridors, &c., having 165, and the dressing-rooms 148. The total number of lamps is 1,178, and, with the 601 blue ones, 1,779. The lamps are arranged in parallel on three circuits, one of which is in parallel with a circuit containing two arc lamps, which are used outside the theatre; these take 40 amperes. The plant consists of three Siemens' dynamos of the S.B. type, each giving 400 amperes at 93 volts. The dynamos are driven at 700 revolutions by two Marshall portable and one Robey semi-portable engine, each of 20 h.p. The switch-board is placed in a corner of the stage. The lamps in the auditorium are lowered by inserting resistance in the external circuit, there being other lamps on the same circuit. Some other groups of lamps, which have to be raised and lowered separately, are done in the same way. The raising and lowering is effected by means of four eight-way switches. The wiring is done in such a manner as to minimise the risk of fire, the leads nowhere crossing and being kept a considerable distance apart. There are safety fuses in each branch main, but no double pole fuses are used, but *each* main lead from the engine-room is supplied with a fuse. There are pilot lamps in the engine-room to each circuit. No gas is used in this theatre behind the curtain.

The other theatres are only partially lit on the stage. The Prince of Wales' Theatre has a set of plant, consisting of a 12 h.p. Clark gas engine, but, having one of their new back covers, it gives 16 h.p., a Siemens' D1 dynamo, and 108 E.P.S. cells of the 31 L type, of which three 59 plate cells have been in four years. Lately leads from the Grosvenor Gallery have been brought into the theatre, and the current is obtained from there, the plant now being used only in case of a Grosvenor break-down. The float contains 54 lamps, and there is one batten of 16 lamps. The front of the house, offices, &c., contain 346 lamps; they are all 100 volts and 16 c.p. There are two 150 light converters. The total number of lamps is 416.

The Alhambra has just had the electric light installed in the auditorium, and a little on the stage. The plant consists of two Crossley 9 h.p. gas engines, driving two Edison 150-light dynamos. There are 108 Elwell-Parker accumulators, 56 of which are used to light the balcony, and the other 52 are used in parallel with the two dynamos. The only lights on the stage are the floats, containing 80 lamps, and one batten containing 80, this being only used in the last scene of the ballet "Enchantment." The whole installation contains about 300 lamps, the only gas in the auditorium being in the dome.

The Haymarket is supplied from the Grosvenor, but no lights are used on the stage with the exception of a temporary festoon used in one act of "The Pompadour." The installation contains about 120 lamps in the auditorium, and two arc lamps used outside the theatre.

The last place—viz., the Pavilion Music Hall—has no electric light at all on the stage; but there are about 300 lamps distributed over the auditorium. The plant consists of two 16 h.p. Otto gas-engines and two Edison-Hopkinson dynamos, and a few accumulators for the sake of regulation.

Taking a summary of the various theatres and music-halls, we find that six obtain current from the Grosvenor, and five have their own plant. Out of the six Grosvenor installations, four of them keep gas burning, while the other two have private plant.

In the foregoing remarks I have endeavoured, as far as my ability would allow, to bring before you the present state of electric lighting in our London theatres; and, in conclusion, I would remark that the successful lighting of our theatres and public places by electricity may be looked upon as the forerunner of the universal application and use of this light, wherever practicable, in our houses, and more particularly in the mansions of our nobility, &c., where there is a wealth of paintings and historical portraits, documents, &c., for so surely as the efficiency and comfort is seen and felt in our places of public amusement, so surely will it follow and be enjoyed in the homes of our people. In fact, as it has been said, "Nowadays nothing can be done without advertising," we may look upon the theatre-lighting as a huge advertisement of the electrical profession generally.

THE GRIFFIN GAS ENGINE.

The following is the report on tests of a "Griffin" patent double-acting horizontal gas engine, of Messrs. Dick, Kerr and Co., by Prof. Andrew Jamieson, M.I.C.E., F.R.S.Edin. &c.:—

Gentlemen,—I have now the pleasure of reporting to you on the results of my examination and tests of your 8 h.p. Nominal "Griffin" Patent Gas Engine, as made at your Britannia Engineering Works, Kilmarnock. My tests extended over four hours on November 25th, four hours on November 26th, 1887, and over one hour on January 27th, 1888. The engine illustrated on page 396, in its general style and behaviour more closely resembles that of an ordinary double-acting steam engine than any other gas engine with which I am acquainted, for both ends of the cylinder are closed in, and an impulse is given to the piston every one and a-half revolutions—*i.e.*, combustion takes place at each end of the cylinder alternately every three revolutions of the crank-shaft, when the engine is working under normal conditions. This feature naturally causes the speed of the gas engine to be more constant than single-acting gas engines, and therefore better adapted for driving dynamos or other machinery where constant speed is required. The governing and ignition of the combustible mixture (gas and air) are effected in a manner similar to most gas engines—the former by entirely cutting off the gas supply, and the latter by plain slides. The charging and exhaust valves are of the lifting type. They are actuated by a simple and neat arrangement of cams on a side shaft, which is driven by worm gear from the crank-shaft.

The engine has been specially well designed with a view of transmitting the working stresses to the foundation, and thus avoiding as far as possible any annoyance from vibrations and racking. Great care has been taken to make all the working parts strong and simple, while the workmanship and finish throughout seem to me all that could be desired. Throughout the whole of my electrical test the engine worked very steadily; in fact, I have never before tested a gas engine which maintained such uniformity of speed at full power, no pulsation or blinking being

observable in the incandescent lamps. The mechanical efficiency or ratio of brake horse-power to indicated horse-power, as shown by the following results, is equal to 78·7 per cent., thus proving that but a comparatively small proportion of the whole power developed is absorbed in working the engine itself. The engine is very powerful for the so-called "nominal" horse-power (a term still common among gas engine makers); in fact, it develops very nearly double the nominal horse-power on the "brake." The absolute and the practical efficiencies or ratios of indicated horse-power, and of brake horse-power to gas consumpt in terms of heat units (as demonstrated in the appendix), are respectively equal to 19·2 per cent. and 15·1 per cent.; which results are better than I have obtained from any other gas engine.

The following tests were mainly directed to two objects, viz.:—1st, to obtain simultaneously the indicated and the brake horse-power; 2nd, to obtain simultaneously the indicated and the electrical horse-power.

The following instruments were used by me in obtaining data for my results, viz.:—

1. A Richard's indicator, of Elliot Brothers' make, with spring yielding $\frac{1}{84}$ of an inch per lb. of pressure per square inch, was used for taking the pressure diagram from each end of cylinder at intervals of about five minutes during the various tests for the indicated horse-power.

2. A revolution counter, of Schaffer and Budenberg's make, was fixed direct to the slide-valve shaft, whereby the exact number of revolutions was obtained.

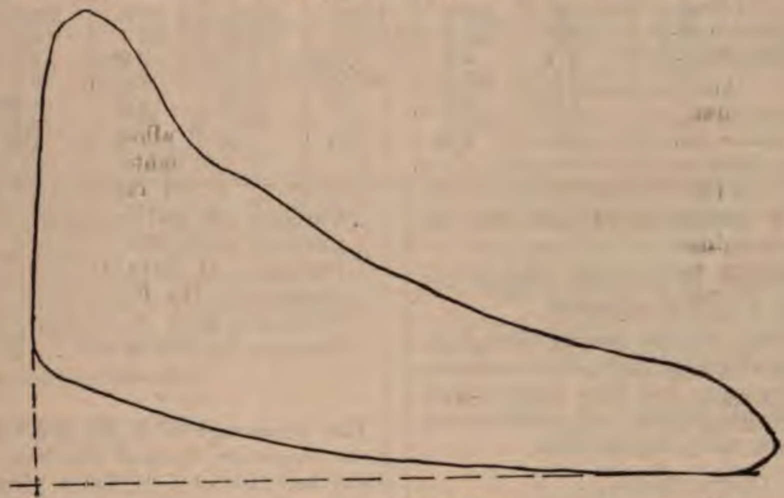
3. A Young's tachometer, of Elliot Brothers' make, was connected to the crank-shaft, and another to the dynamo spindle, as a check on the mean revolutions per minute, and to indicate variations of speed.

4. A gas meter (Alder and Mackay's), 80-light, sealed and certified correct by an Edinburgh gas company's official, was used to measure the gas supply for developing the power. A separate small meter was used for the pilot and ignition lights.

5. Two Fahrenheit's thermometers were employed to indicate the rise in temperature of water passed through the cylinder jacket, one being placed on the supply tank, and the other where the water left the cylinder jacket.

6. A water supply tank, fixed a short distance from and a few feet above the cylinder of the engine, with a regulating cock close to the same, was used to give any desired flow of water through the cylinder jacket. The quantity of water passed through the cylinder jacket was reckoned by careful measurements of the fall of water in the tank every five minutes.

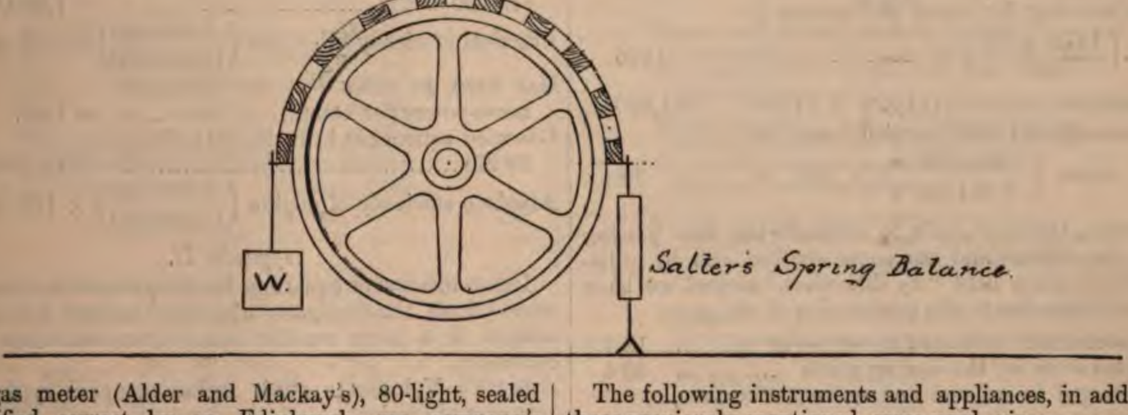
7. The brake used was of the form shown by the sketch below, and one was placed on each fly-wheel. It consists merely of a strap and blocks, with the dead weight on the one side, and a spring balance attached to the floor on the other. The load on each wheel, as well as the several dimensions, were as nearly as possible the same. The mean reading of the spring balance, plus part of the weight of the spring balance, was deducted from the dead weight, to arrive at the net brake load on each wheel.



Diagram—Griffin Gas Engine.

Brake Tests.

Duration of test in minutes	60
Total revolutions in 60 minutes	11,016
Mean revolutions per minute (n)	183·6
Mean effective radius of brake load, in feet (r)	2·78
Mean net load or brake, in lbs. (p)	140
Brake horse-power from above $\left(\frac{2\pi r n p}{33,000}\right)$ ...	13·6
Number of indicator cards taken	12
Mean effective pressure from 12 cards, in lbs...	64
Indicated horse-power from above	17·28
Gas used by engine in 60 minutes, in cubic feet	333
Gas consumption per brake horse-power	24·48
" " indicated "	19·27
Percentage efficiency of engine $\frac{\text{brake h.p.}}{\text{i.h.p.}} \times 100$	78·7



The following instruments and appliances, in addition to those previously mentioned, were used, viz.:—

1. *Dynamo.*—One of the fly-wheels was connected direct by belt to a Rankin-Kennedy single-magnet horseshoe compound-wound dynamo of about 8,000 watt-power, which was kept running steadily at about 800 revolutions per minute.

2. *Lamps.*—In parallel circuit with the dynamo were placed eight large incandescent lamps capable of giving

TABLE A.

Volume of Gas.	Hydrogen, H.	Carbonic Oxide, CO.	Marsh Gas, CH_4.	Ethylene, C_2H_4.	Tetrylene, C_4H_8.	Carbonic Acid and Oxygen.	Nitrogen.	Total.
Cubic feet in one cubic foot of gas	·441	·041	·434	·037	·018	·C05	·024	1·0 cub. ft.
Heat evolved per cubic foot in B.T.U.	343·82	342·03	1066·7	1677·6	3063·6	—	—	
Heat evolved by given amount of each	151·6	14·02	462·9	62·07	55·14	—	—	B.T.U. 745·73

TABLE B.—MOVEMENT OF PISTON IN PERCENTAGE OF STROKE.

—	0	5	15	25	35	45	55	65	75	85
v	0	44 5	133·5	222·6	311·5	400·5	489·5	578·5	667·5	756·5
V	404·0	448·5	537·5	626·5	715·5	804·5	893 5	982·5	1071·5	1160·2
Log V	2·606	—	2·73	2·8	2·855	2·906	2·95	2·99	3·03	3·06
P	—	—	159·7	124·7	107·7	87·7	77·7	68·5	60·7	53·7
Log P	—	—	2·203	2·1	2·03	1·94	1·89	1·84	1·78	1·73
p	57·7	—	39·7	31·7	25·7	22·7	19·7	18·5	16·7	—
Log p	1·76	—	1·60	1·50	1·41	1·36	1·29	1·27	1·22	—

500 candles each, with 12 amperes at 80 volts and one 16-candle lamp.

3. *Voltmeter.*—The difference of potential between the terminals was measured by a Cardew voltmeter.

4. *Current Meter.*—The total current passing through all the lamps was measured by a Siemens electro-dynamometer. The voltmeter and ampere-meter had been tested before leaving the Woodside Electric Works, and simultaneous readings were taken on each, every five minutes.

Tests when Driving Dynamo.

Duration of two tests combined, in minutes.	45
Revolutions of engine fly-wheel, per minute.	187·7
Mean pressure in cylinder, in lbs. per sq. in.	63·2
Indicated h.p. (from above data)	17·4
E.M.F. at lamp terminals, in volts	79
Current through all the lamps, in amperes...	92
Electrical h.p. spent on all the lamps	9·74
Ratio of electrical to indicated h.p. %	55·8
" " brake h.p. %	71
Gas used in cubic feet per hour (without including pilots)	333
Gas used in cubic feet per minute $\left(\frac{333}{60}\right)$...	5·55
Heat equivalent of the 5·55 cubic feet of gas used per minute, in ft. lb. (5·55 × 691 × 773)	= 2,964,500
Water passed through cylinder jacket, in lb. per hour	1,272.4
Mean rise in temperature of the above water in Fah.°	55
Heat carried away by water per minute in B.T.U. $\left(\frac{1272 \times 55}{60}\right)$ =	1166
Heat equivalent in ft. lb. (1166·4 × 773) =	901,600
Percentage of total heat carried away by jacket water $\left(\frac{901,600}{2,964,500}\right) \times 100$ =	30·4

It remains, therefore, only to estimate the heat passing away in the exhaust and scavenger strokes, and by radiation, which is done here "by difference," so that we have of the total heat due to the combustion of the gas:

I. Converted into indicated horse-power	19·2%
II. Carried away by the cooling water	30·4
III. Discharged in exhaust and scavenger strokes, and by radiation	50·4
	100

Appendix I.—Determination of the Heat evolved per cubic foot of gas used during the Tests.

A sample of the gas was analysed by Mr. C. J. Wilson, F.I.C., F.C.S., and gave the following results:—

Carbonic acid and oxygen gas	·5
Carbonic oxide, CO	4·1
Olefines, C_2H_4 and C_4H_8	5·5
Marsh gas, CH_4	43·4
Hydrogen, H	44·1
Nitrogen (by difference)	2·4
	100·0

The percentage of C_2H_4 and C_4H_8 should have been given separately, because the heat value of C_2H_4 is only about half that of C_4H_8 for a given volume. Assuming, however, that two-thirds of the olefines is C_2H_4 and one-third is C_4H_8 (which is probably not far from correct), we have the results shown in Table A.

This is the amount of heat evolved by the complete combustion of one cubic foot of the gas measured at 14·7 lb. pressure, and 32° F., but the pressure was 14·8 lb. per square inch, and the temperature, 67° F., hence the heat evolved per cubic foot of the gas used will be

$$= 745{\cdot}7 \times \frac{14{\cdot}7}{14{\cdot}8}\left(\frac{460+32}{460+67}\right) = 691 \text{ B.T.U.}$$

Taking one B.T.U. as equal to 773 ft. lb., the heat evolved by the complete combustion of one cubic foot of the gas is equivalent to 691 B.T.U. × 773 = 534,500 ft. lb.

Heat evolved by complete combustion of 1 cubic foot gas	= 534,500ft. lb.
Gas used in cubic feet per brake horse-power, per hour	= 24·48
Gas used equivalent in ft. lb. (534,500 × 24·78)	= 13,085,000
One horse-power in ft. lb. per hour (33,000 × 60)	= 1,980,000
Practical efficiency of engine $\left(\frac{1,980,000}{13,085,000}\right) \times 100$	= 15·1%
Gas used in cubic feet per indicated horse-power per hour	= 19·27
Gas used equivalent in ft. lb. (534,500 × 19·27)	= 10,300,000
Absolute efficiency of engine $\left(\frac{1,980,000}{10,300,000}\right) \times 100$	= 19·2%

Appendix II.

Determination of equations for compression and expansion curves from the indicator diagram attached (which is a sample of a large number taken from both ends of the cylinder).

Let V = Volume in cubic inches occupied by the gas at any part of stroke.

L v = Volume in cubic inches through which piston has swept from end of stroke.

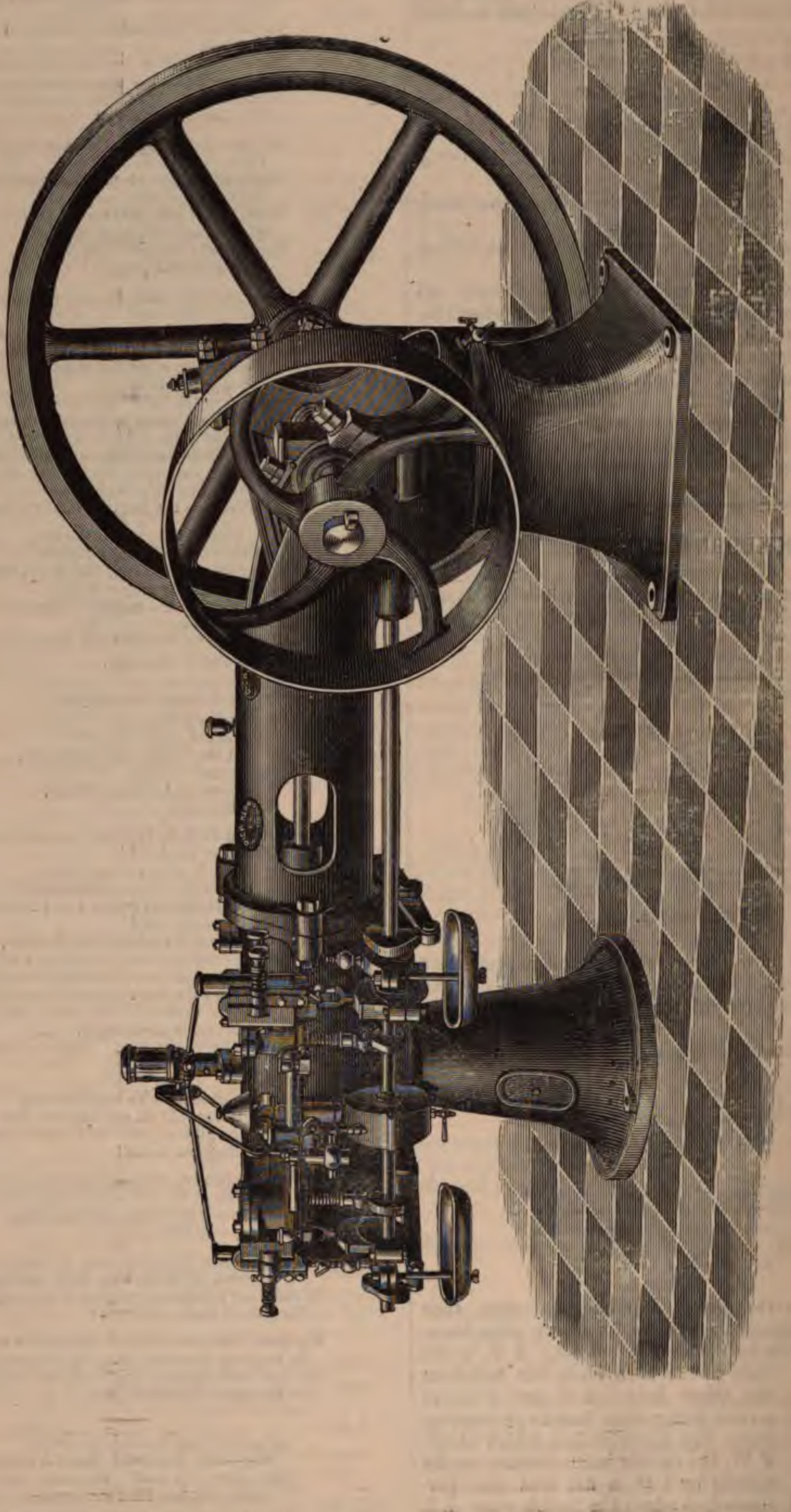
∴ V = v + 404 (where 404 cubic inches is the volume of clearance space at back end of cylinder).

Total volume swept by piston = 890 cubic inches.

P = absolute pressure on expansion curve.

p = absolute pressure on compression curve (*see* Table B).

THE "GRIFFIN" GAS ENGINE.



(For details see page 392.)

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and last week we give that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparati[illegible] [illegible]e hope soon to have ready that of* PROF. D. E. HUGHES, [illegible]

COMMISSIONS.

This is one of the most interesting, and at the same time one of the most dangerous, subjects to discuss. Business sees far too much of interest, discounts, and commissions, and yet all this *finesse* seems necessitated by the modern methods of trading. "That is the lowest price nett" is a phrase seldom heard, but if it is ever uttered, it is usually a case of repentance before the hour. The purchaser takes the "nett" price and the time as well, chuckling to himself that he has this morning done a good stroke of business. It is, however, almost entirely of commissions that we desire to write. When are commissions to be expected, and to whom should they be paid? They may be, and frequently are, claimed by those who have no legitimate right to them, and they are as frequently paid to such parties, though with a mental reservation and possibly an unspoken opinion on the part of the payer. Political economists are happy when discussing questions relating to division of labour, and we all remember the gusto with which one of the greatest of them described the manufacture of pins. But may there not be too great a division of labour, and hence, in the matter of business, too many middlemen? The manufacturer, for example, seldom comes directly into contact with the consumer, and as there must be a profit to every middleman between the two, the last selling price may be something very different to the manufacturer's selling price. Another question might appropriately be dragged in here—that of price lists. To the outsider a price list is usually a hidden mystery. The quotations of discount "off" the list vary considerably to the individuals seeking information, and among the reasons why the real prices and the list prices differ so much is this one of commissions. Consider two claimants for commission. A is a man who thinks B ought to install the electric light into his house, and approaches him on the subject, expounding its advantages, and ultimately, after a good deal of trouble, time, and expense, gets B into the right frame of mind. B asks A the firm or person he recommends, and is told, C. On the other hand, suppose that while B is in the right frame of mind he happens to meet D, and in conversation speaks of what he is thinking, as is not unfrequently the case, D hears and casually suggests C, or, it may be, rushes off to C, telling him of the purpose of B, and claiming commission. The work is put into C's hands, and A also claims commission. Is C to pay both or only one, and, if so, which one? There is not the slightest doubt in the case specified but that A has really done the work, and that D, if he gets commission, gets paid for work he has not done. The case may be still more complicated, in that B applies to C direct, mentioning neither the name of A nor D, but of some client of C's, and, after the work is done, A and D, or either, claims com-

mission. It may be, and often is the case, that B, applying direct, gets better terms than if it is known a commission has to be paid. So that if the claim for com. is subsequently met, C may be a considerable loser. We know of a case relating to the lighting of the yacht of a wealthy man, when six or seven commissions were demanded, and had to be paid. The contractor was bluntly told price was no object, but the payment of these commissions was a *sine qua non*. No doubt the amount for the electric lighting was lumped with other items for fitting, so that the owner never knew, and never will know, what the work cost him. If we might venture to surmise, the contractor did not get for himself more than 50 per cent. of his bill. It is said that backsheesh is all-powerful at Constantinople and in the East generally; but we are bound to say, from a considerable experience, that the *argumentum ad hominem* is quite as well understood in England as elsewhere, and, of course, all goes under the name of commission. Firms of repute, as well as individuals, are beginning to make a trade in, and at every opportunity to claim, commission; and this in cases where they have no power to divert business in any particular direction. It is impossible to be more definite in discussing this question, because remarks intended to apply generally would undoubtedly be applied to individuals, and at present it is neither our wish nor our intention to single out individuals for animadversion. The principle of commissions is a good one when not carried to excess; but, like all other good things, it may conduce to greater harm than good if not taken in moderation. With the advent of the millenium, commissions will cease; at present they are a necessary evil.

MAXIM-WESTON.

There was a lively meeting of shareholders on Wednesday to hear the report of the Committee of Investigation, but there are two sides to the moral, just as there were two sides in the case of the boys and the frogs. The shareholders have supported the Committee and carried their report, which no doubt produced fun enough for the boys, but what about that chameleonic chairman and his colleagues? Will they be in the position of the frogs, and will henceforth their place in electric light companies know them no more? They have had full swing for some years, have, according to their own showing, rescued the company from the Slough of Despond—and paid dividends. It were not wise, perhaps, to enquire too closely into the how they managed to pay dividends, though sarcastic folks say it is an easy matter to do so when you write off your capital, call up fresh capital, make your own balance-sheet, and in it put your own value upon stock, etc. Some, indeed, have been rash enough to suppose the stock has been valued at its list retail price, and not at its actual cost price; but, of course, this is purely imaginary. We are not quite sure but that Mr. Hugh Watt, M.P., will regret having left his unique sphere among mining companies to rescue from the clutch of the official receiver an electric light company. Speculators in mining properties expect a few ups and downs, and are inured to a variety of changes rather foreign to electrical work, so that they are somewhat indifferent to the vagaries of directors. Shareholders in electrical companies have not yet been able to emulate the mining properties in getting hold occasionally of undoubtedly good paying concerns, hence their anxiety to save from the hands of the spoiler what few bawbees may be left.

The report of the committee will be found in another column. It is as suggestive from what it does not say as from what it does say. Fancy a duly elected committee not being able to get hold of the minute-book. What a bold step to take to say the balance-sheet submitted was misleading; that one of the directors was not duly elected; and that the value on the stock was scarcely accurate. Pleasant reading this for those who had pinned their faith upon the success of the company. It seems, too, after all, that the Watt dynamo and lamp are not so entirely separate from the company's operations. The committee and the shareholders hold that these patents are really part of the company's assets, though they say it in rather an ambiguous manner. All along the line the management is condemned, and we believe justly. The business has cost too much, and, shall we add, the work that has been done has seldom been done sufficiently well to please the fastidious tastes of the critics. Our crime in the eyes of the management is very gross. We declared against the action in relation to the City lighting; we say that the workmanship of installations we know of is bad, that new work is obtained at a very great cost, and then only by tempting people by ruinously low prices, so that the company is being bled both ways. A company so managed is detrimental every way, whether we consider the shareholders, buyers, or the industry of which it forms part. There is in our estimation no chance of renovating the company by the addition of new blood on the directorate. The only plan is to sweep away the present directors, and commence *de novo*.

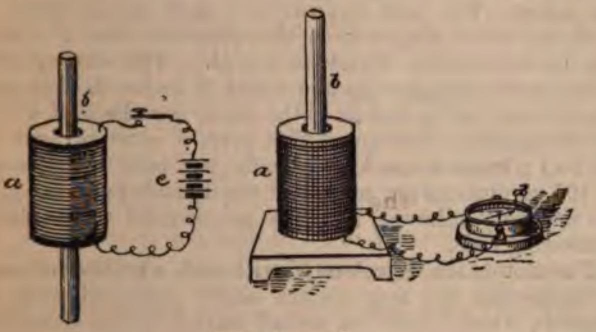
EXPERIMENTS ILLUSTRATING THE PRINCIPLE OF THE DYNAMO.

BY GEO. M. HOPKINS.

The great development of electricity in recent years, especially in the line of electric illumination, has served to add lustre to the name of the immortal Faraday, and to show with what wonderful completeness he exhausted the subject of magneto-electric induction. Since the close of his investigations no new principles have been discovered. Physicists and electrical inventors have merely amplified

his discoveries and inventions, and applied them to practical uses. The number of those who are familiar with the discoveries of Faraday and their bearing on modern electrical science is not only large, but rapidly increasing, but there are those who are still learners, to whom new things, or old things placed in a new light, are ever welcome. To such, the single experiments here given may be an aid to the understanding of induction as developed in dynamos and motors.

Anyone at all acquainted with electrical phenomena knows that a hardened steel bar, surrounded by a coil of wire, which is traversed by a electric current becomes permanently magnetic. It is perhaps unnecessary to



FIGS. 1 AND 2.

reiterate the accepted theories of this action, as they are well established, and appear in almost every text-book of physics. The fundamental magneto-electrical experiment of Faraday was exactly the reverse of the operation of producing a magnet by means of an electrical current. That is, it was the production of an electrical current by means of a magnet and coil. In the first instance, the magnetising power of the electric current is employed to bring about the molecular change in the steel bar, which manifests itself in polarity. In the second instance, the magnetised steel bar is made to generate an electric current in the wire of the coil. In the first instance, the current moving in the wire of the coil induced magnetism in the steel. In the second instance, the movement of the magnetised steel within the coil induced a current in the wire.

The method of magnetising a bar of steel is clearly shown in Fig. 1, in which *a* is a helix of six or eight ohms resistance, *b* the bar of hardened steel, and *c* a battery of four or five elements. A key is placed in the circuit, but the ends of the wires may be made to serve the same purpose. By closing and opening the circuit while the steel bar is within the coil as shown, the bar instantly becomes magnetic. When the coil is disconnected from the battery and connected with a galvanometer, *d*, as shown in Fig. 2,

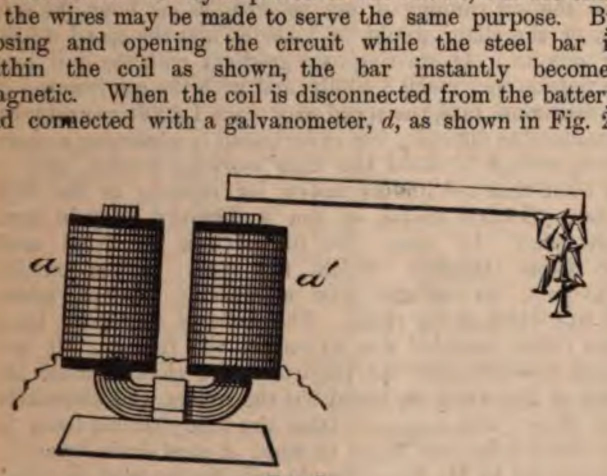


FIG. 3.

and the magnet *b*, is suddenly inserted in the coil, the needle of the galvanometer will be deflected; but the action is only momentary. The needle returns immediately to the point of starting. When the magnet is quickly withdrawn from the coil, the needle is deflected for an instant, but in the opposite direction, and, as before, it immediately returns to the point of starting. It is obvious that if these electric pulsations can be made with sufficient rapidity to render them practically continuous, and if they can be corrected so that pulsations of the same name will always flow in the same direction, the current thus produced may be utilised.

Before proceeding further with the consideration of magneto-electric induction, it will be necessary to briefly examine the subject of magnetic induction, as it is intimately connected with the action of the dynamo. In Fig. 3 is illustrated the usual experiment exhibiting this phenomenon. An electro-magnet is connected with a suitable battery, and a bar of soft iron is held near, but not in contact with one of the poles of the magnet. It becomes magnetic by induction, the end nearest the magnet being of a name different from that of the pole by which the in-

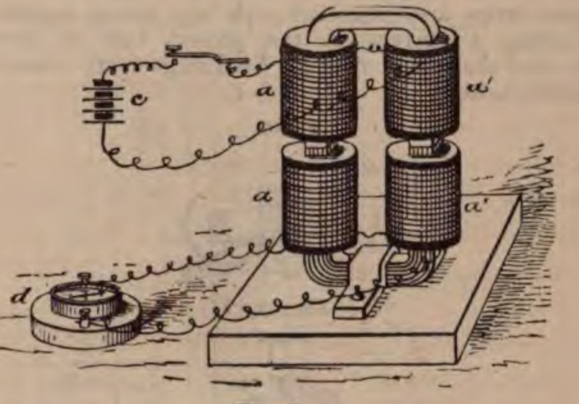


FIG. 4.

duction is effected. The end of the bar remote from the magnet exhibits magnetism like that of the magnet pole of the magnet.

The relation of magnetic induction to magneto-electric induction is clearly shown by the experiment illustrated in Fig. 4. In this case two electro-magnets are arranged with their poles in contact. One of them is connected with a galvanometer, and the other with a battery. When the circuit of the upper magnet is closed, the core of that magnet becomes magnetic, the core of the lower magnet becomes magnetic by induction, and the galvanometer needle is deflected. When the circuit of the upper magnet is broken, the galvanometer needle is deflected in the opposite direction, showing that the results are precisely the same as in the experiment illustrated by Fig. 2. In

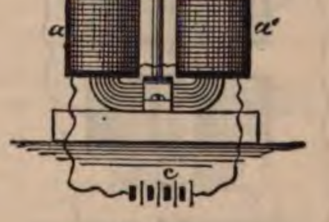


FIG. 5.

this case no mechanical movement is necessary, as the magnetism is introduced into the coils of the lower magnet by induction. It is thus shown that it is not necessary to move any matter to secure magneto-electric induction.

In Fig. 5 is shown an arrangement of electro-magnets, in which one is fixed, while the other can be revolved. It is a device intended simply for showing how two ordinary electro-magnets may be utilised to advantage in experiments in induction.

To the polar extremities of the fixed magnet is fitted a wooden cross-bar, having in its centre an aperture for receiving the vertical spindle, the lower end of which is

journaled in the clamp that holds the fixed magnet to the base. The upper end of the spindle is provided with a yoke for holding the movable magnet. The cross-bar which clamps the magnet in the yoke is held in place by two screws (as shown in Fig 7), and to the centre of the cross-bar is attached a wooden cylinder, *e*, axially in line with the spindle. To the wooden cylinder are secured two curved brass plates, which are connected electrically with the terminals of the coils, *a a'*, of the movable magnet, one plate to each coil. Two strips of copper, *g g'*, held upon opposite sides of the cylinder, complete the commutator. The copper strips are connected with any device capable of indicating a current—in the present case an electric bell—and the coils, *a a'*, of the fixed magnet are connected with the battery, *c*.

FIG. 6.

Fig. 7.

By turning the upper magnet, the following phenomena will be observed: 1. When, by turning the movable magnet, its poles are pulled away from the fixed magnet, the departure of the induced magnetism from the core of the movable magnet produces an electric pulsation in the coil, which operates the electric bell. When, by a continued movement of the magnet in the same direction, the poles exchange position, another electrical impulse will be induced, and the bell will be again operated. 2. By examining these impulses by means of a galvanometer introduced into the circuit, it will be found that they are of the same name. 3. When the magnet is turned a little faster, these two impulses will blend into one, so that for each half of the revolution of the magnet the bell yields but one stroke. By whirling the magnet quite rapidly, the current through the bell magnet is made practically continuous, so that the bell armature is drawn forward toward the magnet and held there.

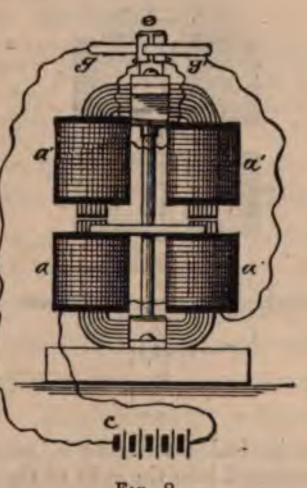


FIG. 8.

From what has been said, it will be seen that all of the positive electrical impulses are generated upon one side of the poles of the fixed magnet, and all the negative impulses are generated upon the other side of the fixed magnet, and that the curved plates of the commutator conduct all of the positive electrical impulses to one of the strips, *g g'*, and all of the negative impulses to the other strip.

In Fig. 8 is shown an arrangement of connections to convert the device into a motor.—*Scientific American.*

ELECTRICAL TRAMWAYS: THE BESSBROOK AND NEWRY TRAMWAY.*

BY EDWARD HOPKINSON, M.A., D.SC., ASSOC. M. INST. C.E.

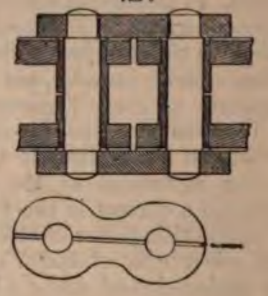
(Continued from page 378.)

MOTORS.

Each locomotive car is fitted with an Edison-Hopkinson dynamo-motor. As previously mentioned, the motor is fixed on the leading bogie, and is entirely independent of the body of the car. The armature shaft carries a double helical-toothed steel pinion, 6·05 inches in diameter, gearing into a steel wheel 21·08 inches diameter, carried on a small counter-shaft running in bearings fixed on the bed of the motor. The shaft also carries a chain pinion-wheel of steel, 8·8 inches diameter, on the extended boss of which the helical-toothed wheel is keyed. The chain-pinion drives with chain-gear on to a wheel 21 inches in diameter, keyed on to the back axle of the bogie, the wheels of which are 28 inches in diameter. This gives a ratio of gear of 8·3 to 1; hence a speed of one mile per hour corresponds to 100 revolutions per minute of the dynamo axle. To give the necessary adhesion, the axles are coupled with outside connecting rods.

The motors are series-wound with such a number of convolutions that the magnets are nearly saturated with 72 amperes, which is also the normal current for the armature. The resistance of the magnets is 0·113 ohm, and of the armature 0·112 ohm; hence, if the potential between the terminals be 220 volts, the electrical efficiency with the normal current is 92·6 per cent., and the commercial efficiency 90·7 per cent., the power developed being nearly 20 horse-power. In actual work the power of the motor frequently exceeds this amount. To transmit this power

FIG. 9



with the car running at, say, seven miles per hour, the tension of the chain would be 1,430lb., and the speed 460ft. per minute. At starting on a gradient with the full load the tension may reach 3,400lb., and with the car running at the maximum rate, the speed may reach 1,300ft. per minute. Considerable difficulty was experienced in obtaining a chain strong enough to stand the high working tension, and at the same time not unduly heavy for running at the high speed. Several chains of the well-known tricycle form were tried. In these the inside link is fitted with two tubes through which the pins of the outside link pass, so as to give a wearing surface across the full width of the chain. The tube is protected by a loose roller, intended also to reduce the friction. It was found, however, that the impact of the chain against the teeth of the wheel flattened out the rollers, and ultimately split them; also, sooner or later, the tube became loose in the inside links, and began to wear. A steel chain, specially constructed by Mr. Hans Renold, was finally tried, in which the tubes were keyed as well as riveted in the inner links, and the pins in the outer, and the rollers abandoned (Figs. 8). The average breaking-stress of the steel is 152lb. per square millimetre (43½ tons per square inch).

Pitch of chain	= 2·125 inches.
Weight	= 8·5 lb. per linear foot.
Strength of pins against shear	= 13·8 tons.
,, outside links	= 10·2 ,,
,, inside ,,	= 14·8 ,,

The wearing surface per foot of chain is 16 square inches, whereas in the ordinary bowl or stud chain of the same strength the wearing surface would not exceed 2·5 square

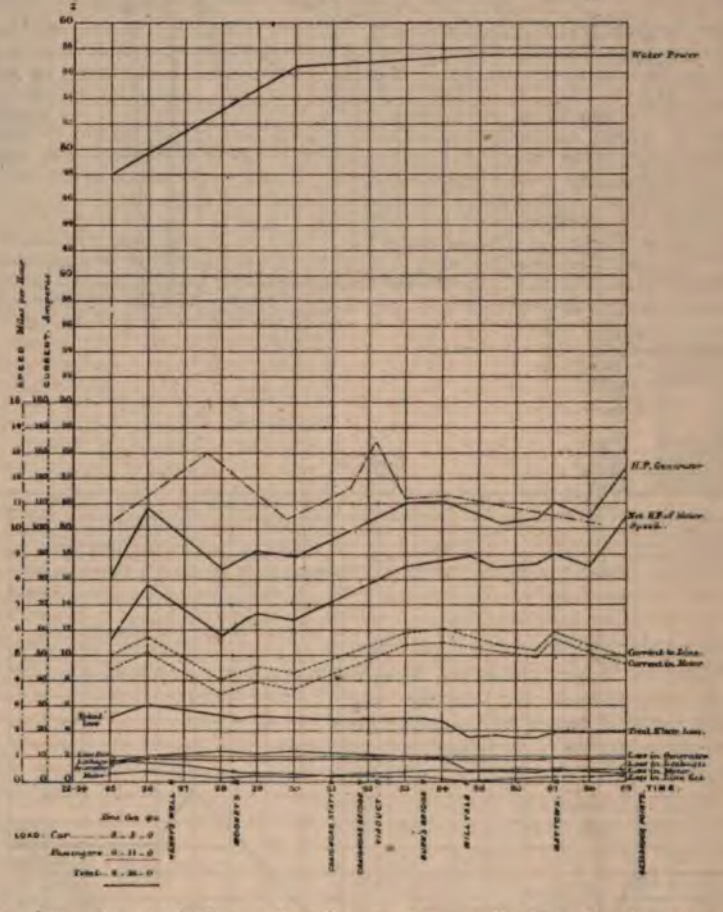
* Paper read before the Institute of Civil Engineers, and reprinted by permission from the *Transactions* of the Institute.

The trains are commonly composed of one locomotive car and three or four trucks, but frequently a second passenger car is coupled, or the number of trucks increased to six. Thus a gross load of 30 tons is constantly drawn at a speed of six or seven miles per hour, on a gradient of 1 in 50.

Efficiency Experiments.

In order to test the efficiency of all the component parts under various conditions of load, several series of observations were made as the car travelled from Newry to Bessbrook with six, four, and no trucks respectively. The flow of water, the potential of the conductor, and the speed of the car were ascertained at frequent intervals, and the results plotted in the form of curves, with the time as abscissa. From these observations, and the known resistances of the generator, motor, and conductor, the loss in the several portions of the system, and the actual power developed by the motor, can be readily calculated, and the results similarly shown in a graphic form. The points representing actual observations are joined by straight lines, though no doubt a line of continuous curvature would more

Fig. 3



accurately represent the fact; but the method employed has the advantage of distinguishing at a glance observation from interpolation.

The curves, Plate 1, Fig. 1, give the results for a journey with a gross load of 28 tons 12 cwt. 3 qrs., including the locomotive car.

The curves, Fig. 2, for a gross load of 21 tons 18 cwt.

The curves, Fig. 3, for a gross load of 8 tons 16 cwt.

Hitherto, writers on electrical locomotion have considered the question of mechanical efficiency from individual observations made at a given instant, when the conditions might or might not be favourable. By a suitable choice of conditions it is very easy to deduce extraordinary high figures of efficiency for electrical working; but such figures are misleading, and not a fair basis of comparison with other modes of locomotion. Since the conditions are constantly varying between very wide limits, any calculation of efficiency ought to take account of the average conditions, or, in other words, the results of a series of individual observations taken at intervals ought to be integrated in respect of time. The curves enable this to be readily done by determining the areas bounded by them and the axis of abscissas. The results are given for the three series of curves in Tables I., II., and III. in the Appendix.

Table IV. in the Appendix also gives the results of the integration for the three journeys, showing the work done by the water, the electrical energy developed by the generator, the loss in leakage, resistance of line, magnets and armature of generator and motor respectively, and the mechanical work done by the motor, all expressed in foot-lbs. Table V. gives the results in Table IV. tabulated as percentages of the total energy of the water, and also of the electrical work done by the generator. It will be observed that the efficiency of the whole combination varies from 26·1 per cent. for the light load to 41·3 per cent. for the heavy load; whereas the efficiency of the electrical portion varies from 69·4 per cent. for the heavy load to 76·8 per cent. for the light load. This is explained entirely by the very low efficiency of the turbine when running with a light load. When loaded to nearly its maximum capacity, its efficiency is 60 per cent., which is not unfavourable, considering that the load is constantly varying, and that the friction of the shafts, belts, and dynamos, as also the power required to drive the governor, are included. Considering the problem as an electrical one only, it appears that the efficiency does not vary greatly with the load, falling only from 76·8 per cent. to 69·4 per cent., as the load is more than trebled. Taking the average of the three journeys:—

Electrical efficiency	= 72·7	per cent.
„ loss in generator	= 8·6	„
„ „ leakage	= 5·7	„
„ „ line resistance	= 6·6	„
„ „ motor	= 7·7	„ *

The loss as given above in the generator and motor does not include the friction of the bearings nor the power required to turn the armature in the excited fields when no current is passing through it, both of which, however, are very small.

(To be continued.)

* It will be observed in the tables that the totals given do not always correspond exactly with the sums of the components. This arises from the curves being separately integrated. The error of about 1 per cent is a measure of the accuracy of the method.

"compound up," so the primary pressure should be increased an amount equal to half the full lead loss, so as to split the difference. He (the speaker) did not think the importance of motors was sufficiently taken into account. One difficulty was in starting alternating motors. A laminated field exciter can be used to start the motor, and switched over when the right speed is reached Little was known about insulation on alternating circuits. It was possible that insulation which gave way with 2,000 volts continuous would stand the same alternating, the harm done in one direction being undone next alternation, and so on. As to the drawback of being unable to use storage with alternating systems, he could only quote Mr. Mordey's dictum: "The great advantage of alternating currents is, people cannot go and put in accumulators." The weak point of Mr. Crompton's system was the high pressure led into houses. He believed alternating currents were best for scattered lighting with overhead wires; direct parallel for dense districts; and step-down dynamos, or "dynamotors," for such cases as that taken by the author. Dynamotors need little or no attention, and they will regulate, or even compound up, with a varying primary pressure. They get over the high-pressure difficulty, and have the doubtful advantage of admitting accumulators. The safety of people on transformer secondaries had been already considered. To make the installation safe, however, none of the circuit should be earthed permanently, but a contact should occasionally be automatically made between first one terminal and earth, then the other terminal and earth. In case of a leak, a bell would be left ringing, no further contacts being made. In the case of alternating currents, the contacts are made through a toothed wheel synchronising with the machines, so that capacity shocks do not interfere with the working. If a man makes an earth contact, he is then immediately shunted to earth and set free.

Major-General Webber, C.B., R.E., drew attention to the difficulties he foresaw in connection with Mr. Crompton's proposed subways. Such an arrangement would not be watertight, and after two years the accumulation of detritus would cause the insulation to disappear. The bare conductors could only be got at by opening up the roadway except at the connection boxes, and he could not consider the maintenance of any underground conductors that were not capable of being withdrawn in the same way as telegraph conductors were laid down, a purpose for which the Callender bitumen concrete tube was specially suitable. He considered Mr. Crompton's estimate of 20 yards of main cable required for every house as excessive by three yards.

Mr. Sidney F. Walker took the object of the paper as leading onward towards the progress in electric lighting which engineers were looking forward to in the current year, and the question of accumulators v. transformers was applicable to installations of less than 10,000 lights. There was progress needed in the lamp itself before those matters could give material help. The introduction by Mr. Swan of a 200-volt lamp would quarter the cost of the copper in the cable, and a 400-volt lamp would quarter it again. He was afraid that the varied voltages of the lamps at present in use was the result of progress, and could not be helped. His experience led him to consider that the essential thing to be studied commercially was what was known as the efficiency of the service. When a good thing was produced, a sufficient number of customers would always come forward to pay for it, but they would not put up with breakdowns every now and then such as had been referred to by Sir David Salomons. A consumer might be told that the efficiency was 99·9 per cent., and he might take an interest in it; but if the system broke down he would vote it as being a marvellous nuisance, though it was a marvellous thing. The difficulty with transformers was that before the service of 2,000 volts could be properly dealt with, the problem of providing efficient insulation for it must be faced. The service must not be insulated for temporary use, but for a permanency as long as the system lasted. The difference in the insulation—heavy and light—for the same size of conductor did not provide for a pressure of 2,000 volts. He agreed with General Webber as to the difficulties to be expected with the subways, and he suggested that, instead of using a large cable, it would be better to employ small cables, so that each could have its own small engine and small dynamo. His experience of continuous current dynamos in parallel was that they did not work properly together. If, in working with two such dynamos coupled in parallel, one happened to be half a volt before the other, it would take much more current than its fellow because the second could not deliver until the first one had ceased to compound.

Mr. Robert Hammond considered that the question raised by Mr. Crompton was the crucial problem that confronted all those who had to do with central station work, and which had confronted them in the immediate past. The installation at Eastbourne had been mentioned, and he might state that some two years ago it was suggested to light the Town Hall there in such a way that any portion of the lamps could be running, or the whole 300, at the same time By the grouping arrangement, under which the system was then working, such conditions were impossible, and it was necessary to consider whether it was best to put batteries into the Town Hall which could be charged with the high-tension current, or to use converters or transformers. Transformers were decided upon, and the lighting of the Town Hall was carried out, had continued to work satisfactorily, and he looked to the installation with great pride. In reading Mr. Crompton's paper he was surprised to find it stated that the installations at Eastbourne and elsewhere had been "confessedly carried out in a temporary manner for the purpose of popularising the electric lighting, and inspiring the confidence of the public in supply companies as a form of investment." If in the Eastbourne installation they had struggled for anything during the last five or six years, it had been to pay a dividend to those who had invested their money in the concerns; and had Mr. Crompton seen the list of shareholders he would have hesitated before making what he could not help feeling was an unkind remark. In one paragraph Mr. Crompton said, "It is hardly to be wondered at that what little knowledge exists on this subject should be confined to *the few who have lighting stations* under their immediate charge," while in the next he in effect said, Do not take any notice of Eastbourne or Brighton, because they are only a set of advertisers. As Mr. Crompton had taken no notice of those installations in his paper, he (Mr. Hammond) would relate a few facts connected with those two central stations, because they might not be gathered from Mr. Crompton in his reply to the discussion. He had already said that transformers were used, and some 2,000 or 3,000 lights were supplied. He had learned that in starting a central station, scattered lights must be at first provided for, and then gradual additions of fifty or 100 lights might be expected. In estimating for a London central station he had had again to consider whether batteries or transformers should be used, and again he had come to the conclusion that transformers were the best. His order had not been placed, and if Mr. Crompton could convince him that batteries were the best, he was prepared to adopt it. Mr. Crompton had stated that three shifts of men were necessary with transformers, but that was not so, for he had himself seen the central station at Brighton working at its busiest time, and then one engine after another was put down according to the load, and the labour expended was absolutely proportional to the load on the circuit. People who said that with a transformer system it was necessary to have three times the normal staff, were talking of what they would know more about if they went down to Brighton and Eastbourne and saw what was done. Therefore, in point of economy, Mr. Crompton was as far out as he was in regard to the motives that had inspired those installations for the past five or six years. He would say nothing about the Grosvenor Gallery installation, as the people connected with it were very well able to take care of themselves. As to the reserve offered in the battery system, that was only a chemical reserve, and it was a question whether a chemical reserve was better than a mechanical reserve. At Brighton a second engine was always ready, with steam up, to come in at any moment. He asked what probability there was that a steam engine which was well looked after would burst up without any warning. His experience was that a warning was always given, and if the practised eye of the attendant detected a leak, it was attended to. No stoppage had ever occurred through not being able to bring in the reserve power, to do which there was always plenty of time; and the advantage of having a reliable and continuous power rendered the introduction of those wretched accumulators on the circuit unnecessary. Some of the outlying districts were served by accumulators—a fact, perhaps, unknown to Mr. Crompton, as he had not been down to see; but his experience of them was such that he felt they were the one portion of the system to be afraid of. Accumulators were a splendid thing on paper, but in practice they only gave a day-to-day absolute efficiency of 60 per cent., as against the 80 per cent. stated by Mr. Crompton. He could show converters at Eastbourne which gave 95 per cent. efficiency, and any transformer which gave 30 per cent. must be an atrociously bad one. He was anxious to hear what Professor Forbes could say about what was done in America, and whether converters with light loads ever fell from their high efficiency down to 30 per cent. when they were thoroughly well constructed. As to depreciation, experience showed that it was not necessary to put down 10 per cent. on that account for converters. Such an amount was not required for dynamos, and why was it necessary in the silent converter, which had no movable parts, while only 15 per cent. was set down for the depreciation of accumulators? On those four points, therefore, of the load, reliability, efficiency, and depreciation, his experience was dead against Mr. Crompton's statements. One might imagine, when Mr. Crompton said that at "Eastbourne, Brighton, and, in fact, all those which distributed by means of overhead wires," the system at Eastbourne was overhead. That was not so, for there were some seven miles of underground mains used; and in reply to the remark just made, that the insulation must break down at or under 2,000 volts, he could only say that the charging-pressure was 2,000 volts, which were passed through those mains, and they lived through it all.

Mr. A. P. Trotter thought that Mr. Crompton had shaken the faith of many of those who relied on transformers, and he, for one, would not like to say that batteries would not be the system of the future, especially when the time came that motors were generally used. Great improvements had been made in the life and efficiency of batteries. Spare dynamos and engines should always be kept in reserve, and it was discreditable that so few installations existed with such reserve, as its absence had prejudicially affected the progress of electric lighting more than anything else. He considered it unfair to transformers to assume that two out of every three houses would at no distant date take the light.

The discussion was then adjourned until April 26.

PARLIAMENTARY INTELLIGENCE.

THE ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

HOUSE OF LORDS.—MONDAY, APRIL 23.

The House went into Committee upon this Bill.

On Clause 2.

The **Earl of Camperdown** moved to omit the words "The goodwill of the business and of" on the ground that they rendered uncertain the elements of value in the property of the companies to be taken over. He desired at the same time that at the expiration of the period during which the companies' privileges were to endure, their plant and material should be valued as being *in situ* and as suitable for the purposes for which they were intended, instead of being taken over at the "old iron" value.

The **Earl of Crawford** observed that inasmuch as it was understood that the noble and learned lord opposite intended to propose an

been for that letter, I am quite certain a large number of gentlemen present at the last meeting would not have voted for the committee. With regard to the increase on the item of patents, I think I had better give you the three items that were increased in the balance-sheet of 1887 as compared with 1886. In 1886 the patent account was £38,229. 17s. 1d., whereas in 1887 it was written up and placed to credit as an asset to the extent of £40,737. 1s. 1d. That increase is made up as follows:—Cash to Haseltine, £44; wages at works, £718. 4s. Then we have salaries, that means Mr. Watt's experimental works, £750, Mr. Tuff £200; total, £950, written up to credit of patents. Next, there are goods used in experiments, £325; salaries, £100 of the Secretary's salary, £270 office expenses, and £100 general office expenses. These are the items by which your patent account was increased from £38,229. 17s. 1d. in 1886 to £40,737. 1s. 1d. in 1887. The stock of machinery, lamps, &c., at the factory was £13,440 in 1886, whereas in 1887 it was written up to £19,817; the stock, plant, machinery, and tools are £2,970. 4s. 9d. in 1886 and £3,603. 15s. 2d. in 1887. In other words, the stock, patents, and machinery, down at £54,640 in 1886, were written up to £64,158 in 1887. But although we find the stock book has been written up, and increased values placed against machines and other things, as compared with 1886, your committee failed to find the increased value in the stock as compared with 1886. Their own opinion is that instead of being written up, a certain amount should be written off. We very much regret that at the preliminary meetings of the committee a great deal of our time was wasted. I think that to us, as commercial men, that was a pity. There were a great many excuses with regard to the books, the Secretary being out, and Mr. Howell being out, and we had great difficulty in finding either the Secretary or Mr. Howell, and, at times, Mr. Watt. The third paragraph of the report relates to the Directors. We hold we have not gone into any personal matter between Mr. Swaby and Mr. Watt; but Mr. Swaby holds his qualification, and should have retained his seat at the Board. What we find is this: Mr. Brown, the late Director, retired from the Board on March 3, and from February 22 to April 4 he disposed of 1,275 shares. On March 3, after Mr. Brown's retirement, Mr. Swaby not attending the offices of the Company, we consequently hold that all the business done from that time until the present is done illegally, because there was not a quorum of the Board to transact any business. Mr. Brown retires on March 3, and on March 6 Mr. Howell had 250 shares transferred to him by the Chairman; but as there was no Director to sit with Mr. Watt, the Board could not accept Mr. Howell as a Director nor transact any business, according to our opinion of the articles of association. Coming to the fifth paragraph of the report, we say the Board ought to be strengthened. We very much regret that shareholders have not been put in possession of a copy of our report. We made a request to the Secretary that he would address us a set of envelopes, but the Secretary has refused to furnish us with them, otherwise the report would have been in your hands. The notice convening the meeting was only sent out when the committee sent a request to the Secretary to do so. We pointed out that according to the articles of association notice ought to be sent to every shareholder, and that the notice should state that the object of the meeting was to finish the business left unfinished at the meeting on March 23, and that a paragraph had better be inserted as to receiving the Committee's report. All reference to the business and the reception of the Committee's report was studiously avoided. We now come to the most important point of the whole business—that is, that we consider that Mr. Watt should only hold the patents for the Watt dynamo and the Watt arc and incandescent lamps in trust for the Company. He has gained what experience he has in connection with this Company, he has used part of his salary in the experiments, he has used our offices, he has used our works, he has used our machinery, he has used our wages in connection with all these experiments, and we hold that the patents are held, and should only be held, in trust by him for the benefit of this Company. I beg to move the adoption of the report of the Committee.

Mr. G. W. Hilyard (a member of the committee), in seconding the adoption of the report, said he wished it to be understood that he desired to say nothing against the Maxim, or the Weston, or the Watt patent. He held the opinion that, in the future, the electric lighting companies would be much sought after. The business of the Committee had been to look into the accounts. The amount of turnover in 1887 was stated to be £7,500 in round figures, and although he did not complain of that in itself, he did complain of the cost at which the business had been done. He held that there was a loss on last year's working of £2,000.

Mr. Hugh Watt: I think I may state at once that, after consultation, we can do almost nothing at this meeting. We cannot, at the moment, say who are directors of the Company. Either Mr. Brown, Mr. Swaby and myself, or Mr. Brown and myself, or Mr. Swaby and myself, or Mr. Howell and myself, or Mr. Howell, Mr. Swaby and myself, may be; but it is purely a legal question turning upon the articles of association, so that it is quite impossible for you to determine who the Board are, and it is quite impossible, I am told, for this meeting to strengthen the Board. That is a point I should like to refer at once. Personally, I have no animus against Mr. Swaby, Mr. Brown, or anybody else. I have done my best for the Company. (A Voice: "For yourself.") Very well; I am afraid if that is your opinion, sir, you must blame Mr. Swaby. He will agree with me in this, that some time ago, owing to other engagements, and feeling the business too heavy, I was anxious to retire, and I think no one more than Mr. Swaby thought it was in the interest of the Company that I should remain, and Mr. Swaby, more than Mr. Brown, pressed me into an engagement. That engagement, gentleman, is entirely at your disposal. I think I have said before, and I say now, that if Mr. Swaby, his friends, or anybody else, are willing to take over the Company, I have no objection. I have some 8,000 or 9,000 shares, and, from first to last, I have made *no money out of the Company*, notwithstanding the fact that I have *drawn £1,000 a year for my services*. At the last meeting I had with the committee I said I was willing to give up a large portion of my remuneration to a manager who would relieve me of many of the details. I was willing to pay him out of my pocket. The last meeting of the committee was held on April 17. At that meeting I made a statement to that effect, and stated also that Mr. Howell had cost the Company nothing—that I had paid him myself. Of course, I am not going to say anything invidious with regard to the Board, because, as I stated on advice, the Board consists of certain gentlemen, according to the construction to be placed on the articles. We do not know positively who the Board are. It is essential, and Mr. Klenck has sufficient experience of companies to agree with me, that we adhere strictly to the articles of association. It is there provided that seven days' notice before the annual meeting shall be given of new directors. Do not suppose for a moment that I stand in the way in the matter of new directors. With regard to the business we are in this position, that inasmuch as dynamos which can be produced cheaper than ours have been made in 1887, we found it impossible to secure a great many contracts, which judging from the experience of 1886, we had a right to expect. We are consequently in the position as regards turnover as Mr. Hilyard has stated. But, if I may pass to a question of account, this I will say: no doubt we have added to the patents account by the amount stated. I stated that at the last meeting; but if you consider the sum set down under that item is in excess of what it should be, then it must be dealt with in the working expenses. We have most carefully gone into that point. No doubt I have gained experience with this Company, but that experience has not enabled me to work out the Watt system, because I tell you frankly and fairly that the original plans of the Watt system were not of my initiation. They were submitted to me, and I financed a certain amount in connection with them on the distinct condition that the Maxim Company were to benefit thereby. The committee seem to say that the company is nothing without these patents. I say that the patents were brought to me, and Mr. Swaby, even more than Mr. Brown, wanted me to arrange to secure them originally.

Mr. Swaby: I have to deny that.

The Chairman: Then I say the minute was entered relating to it. Mr. Swaby was present, and he did not dissent. I wish to make a perfectly fair statement, and the future of this Company depends entirely upon our arrangements. The provisional arrangement come to with regard to this patent was that you were to make the machines; if you sold them, you were to pay a certain amount of royalty for the plans and specifications put into your hands. If you sold none, you paid nothing. I mention this because I am not aware of any such patent having been arranged on such terms before. Now I come to the committee, and I have in my memorandum book here the result of a conversation, a very long one, which I had with the committee on April 17. That meeting was prefaced by a long conversation as to the accounts of the Company, and Mr. Hilyard distinctly averred that, in his opinion, there was a loss. The general account was prepared on the advice of the auditors and the professional accountant who keeps the books, and all I can say is this, that the more you debit working expenses with amounts incurred in experimental work the less will be your chance of a dividend and profit. That is a question for the shareholders. Let us turn to other companies. In one year I am told that another company debited patents up to a sum amounting to tens of thousands of pounds. I do not say that that was an excessive sum—I am not going to discuss their business; but I say that the sums we have charged to patents, except my own proportion and the manager's, and one or two of the superior officials', have been totaled hour by hour at so much per hour. That is what has been done. The plant used, that is, in winding and unwinding, and so forth—principally the Maxim machine—has expended a certain amount of wire. It is for the shareholders to decide whether our estimates in this matter are correct or not. I think that in a matter of this kind—Mr. Hilyard will agree with me—that is a subject for an expert, hardly a matter for hard-headed business men—where we are dealing with scientific and mechanical as well as commercial principles, it is rather a curious thing to do to place Mr. Hilyard's opinion against mine. I say this with all due deference to him. I have had five or six years' experience in these matters, as he has said, and the result is that my conclusion is what I have already stated I have arrived at. Our accounts are prepared in the same way as those of other electrical companies. What I said before was that we cannot take this business like a butter business, where you produce the same article year after year. You must either work in the van of electricity or you must not. Now, regarding the Watt patents, if you do not have them you will lose them, and providing my advances are paid they will be taken out of my hands altogether. You have made certain machines, and expended a certain amount upon them. Under the arrangement made, which will be carried out, any machines and lamps made remain the property of the Company, or, if you do not want them, your expenditure will be paid you, and there is an end of it.

A Shareholder: What is the royalty?

The Chairman: That is according to the size of the machine.

A Shareholder: What is it per cent.?

The Chairman: I cannot give the percentage; but I can say that, with the percentage, the cost is certainly not more than two-thirds that of the Weston machine. It is a minimum, not a prohibitive royalty. The Company do what business they may on what terms they think fit, the profits to be divided equally between the Company and the patentees. I acted in the matter of these patents, because they did not need to go a begging. I made all the outlay, and the patents are at the disposal of the Company; if the Company does not think fit to take the patents, the patentees are prepared to pay all the Company has expended in making machines. It has not been a question of throwing away money for nothing. To return to the question of the appointment of the committee, the committee were appointed to confer with the Board. It was distinctly understood it was not to be an investigation committee; it was

agreed it was to be a friendly committee to confer with the Board, so as to improve the future position of the Company. Now, I think, the future position of the Company is the question with which we are concerned. At the first interview I had the honour of holding with this committtee, I had a paper put into my hands by a gentleman who was acting as chairman of that committee, desiring to see certain books and papers. I said: "Gentlemen, I take the entire charge of this Company, and, as the Secretary has only been about a year in the Company, and is not so conversant with the past as I am, I shall be glad if you will refer to me on any matters, as I can give you more information than he can, and I will give you any reasonable information as long as the result of it will not be inimical to the interests of the Company." The chairman of the committee handed me this paper, and the books were immediately handed to him. On leaving the room I was told that they would let me know when they wished to see me again. I did not hear from them for weeks, but the next intimation was that they desired to see me at once. In the meantime, I do not know that I would have sanctioned the committee going to individual workmen and getting information to come here and give it to the public. (A Voice: "Why not?") Simply because, sir, I am willing to give every shareholder privately whatever information he may require; but there are in this Company secretaries and officials of other electric companies, and I should certainly not be prepared to give to those gentlemen details with regard to the conduct of our business. I think that answers "Why not."

After a long, rambling, and recriminatory discussion the report of the committee was adopted.

REUTER'S TELEGRAM COMPANY.

The ordinary general meeting of the shareholders in Reuter's Telegram Company, Limited, was held on Wednesday last, at the offices, Old Jewry.

Colonel J. Holland presided, and in moving the adoption of the report stated that the revenue of the past year had been larger by £1,300 than that of 1886, but the expenses showed an increase of £3,400. Hence the decrease in the dividend. In the past year there were several prolonged periods of excitement, entailing considerable outlay, which was not compensated for by extra subscriptions, as would have been the case in the event of actual war.

Admiral the Right Hon. Sir J. C. D. Hay, K.C.B., seconded the motion, which was carried unanimously, and the retiring Director and Auditor were subsequently re-elected.

PROVISIONAL PATENTS, 1888.

April 13.

5493. **Improvements in that class of lights known as "search lights," the same being applicable to other lights of an analogous kind.** William Harvie, 115, St. Vincent-street, Glasgow.

5522. **Improvements in telephonic apparatus.** Adolph Heinrich Gottlieb Segnitz, of the firm of Rösing Brothers and Co., 4, South-street, Finsbury, London. (Ehrhard Brand, Brazil.)

5528. **An improvement in plates for voltaic batteries.** Eugene Hermite, Edward James Paterson, and Charles Friend Cooper, 28, Southampton-buildings, London, W.C.

5529. **Improved construction of reflector for use with incandescent electric lamps to facilitate its removal or readjustment.** Peter Gregory Merry, 166, Fleet-street, London.

5531. **A new or improved system of electric lighting and apparatus therefor.** John Grice Statter, Norfolk House, Norfolk-street, London, W.C.

April 14.

5554. **Improvements in apparatus for covering wire or conductors.** Robert Wood, 1, St. James'-square, Manchester.

April 16.

5640. **Improved means to be used in supplying, distributing, controlling, and indicating electricity for lighting and other purposes.** Henry Edmunds, 47, Lincoln's Inn Fields, London.

April 17.

5681. **Improvements in switches used for electrical purposes.** Charles Scott Snell, Culver Park, Saltash, Cornwall.

5704. **Improvements in switch-boards or apparatus for the distribution of electricity.** John Smith Raworth, 46, Lincoln's Inn Fields, London, W.C.

5708. **Improvements in dynamo-electric machines and motors.** John Lea and Charles Julian, 75, Arlington-road, Camden Town, N.W.

5713. **Improvements in electric elevators.** John Keese Hallock and George Canfield Blickensderfer, 77, Chancery-lane, London, W.C.

5723. **The production of chalybeate waters by electrolytic action and apparatus therefor.** William Webster, 28, Southampton-buildings, Chancery-lane, London, W.C.

5732. **Improvements in, and relating to, apparatus for measuring electric currents, which apparatus will also serve as a motor.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

April 18.

5745. **An instrument for use in making electrical contacts.** Sydney Hall Gillam, Othery Vicarage, near Bridgwater, Somersetshire.

5753. **The Daisy long distance telephone and transmitter.** Gerard Huck, 72, St. James'-street, Burnley, Lancashire.

5764. **Electro motor velocipedes.** Charles Adams Randall, 7, Alfred-street, Montpelier-square, West Brompton, London.

5782. **A new or improved electric arc lamp.** William Charles Mountain, 2, Rothsay-villas, Eglantine-road, Wandsworth.

5783. **Improvements in electrical transformers.** William Charles Mountain, 2, Rothsay-villas, Eglantine-road, Wandsworth.

5790. **Improvements in and relating to the preparation of non-metallic porous bodies for electro-metallurgic deposits.** Hubert Steinach, 18, Buckingham-street, Strand, London, W.C.

April 19.

5811. **Improvements in, and connected with, the generation and distribution of electrical power, chiefly by alternating currents.** Rookes Evelyn Bell Crompton and James Swinburne, Arc Works, Chelmsford.

5831. **Improvements in means or apparatus for lifting, lowering, and regulating the height of the elements in electric batteries.** Theodor Schönherr-Schöner, 2, East-parade, Leeds, Yorkshire.

5848. **An apparatus for performing operations at intervals, applicable to the making of electric contacts, or for analogous uses.** Henry Edmunds, 47, Lincoln's Inn Fields, London.

COMPLETE SPECIFICATIONS ACCEPTED.

April 28, 1887.

6204. **Improvements in induction coils and transformers.** Wm. John Muller, 70, Chancery-lane, London, W.C.

May 25, 1887.

7553. **A method of regulating the electromotive force of dynamo-electric machines.** Frederick George, Uley, Dursley, Gloucestershire.

June 7, 1887.

8181. **Improvements in means or instruments for testing submarine electric telegraph cables or for analogous purposes.** Herbert Arnaud Taylor, of the firm of Clark, Forde and Taylor, 47, Lincoln's Inn Fields, London, W.C.

June 16, 1887.

8708. **Improvements in apparatus for fixing telegraph posts.** Joseph Oppenheimer, Carlton Chambers, 18, St. Ann's-street, Manchester.

August 10, 1887.

10,963. **Improvements in instruments for the measurement of electromotive force and power.** John Ambrose Fleming and Charles Henry Gimingham, 47, Lincoln's Inn Fields, London.

February 20, 1888.

2515. **Improvements relating to dynamo-electric generators and motors.** James Feaveryear, Gray's Inn Chambers, 20, High Holborn, London, W.C.

March 15, 1888.

3995. **Improvements in and relating to galvanic batteries.** Henry Harris Lake, 45, Southampton-buildings, London. (Hugo Walter, United States.)

March 20, 1888.

4274. **Improvements in or relating to storage batteries.** Wm. Phillips Thompson, 6, Lord-street, Liverpool. (Charles David Paige Gibson, United States.)

4275. **Improvements in or relating to storage batteries.** Wm. Phillips Thompson, 6, Lord-street, Liverpool. (Charles David Paige Gibson, United States.)

SPECIFICATIONS PUBLISHED.

1887.

4116. **Electric incandescent lamps.** A. F. St. George and C. R. Bonne. 8d.

4795. **Direct motor wheel for driving carriages, dynamos, &c.** F. F. Lee. 8d.

5862. **Simultaneously driving clocks by magneto electricity.** W. Blenheim. 8d.

5958. **Dynamo-electric, &c., machines.** A. M. Clark. (Maiche.) 8d.

6754. **Dynamo-electric machines.** R. E. B. Crompton and J. Swinburne. 11d.

6917. **Electric transformers induction coils.** W. M. Mordey and C. E. Webber. 8d.

6987. **Electric arc lamps.** A. Siemens. 8d.

7021. **Electro-dynamic machines.** G. Scarlett. 8d.

1888.

112. **Incandescence lamp holders, &c.** H. F. Joel. 6d.

506. **Incandescent electric lamps.** C. M. Dorman and R. A. Smith. 6d.

750. **Electric railways.** H. H. Lake. (Weems.)

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	102
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	4
15 Feb.	10/0	Anglo-American	100	38½
15 Feb.	20/0	— Pref.	100	64½
12 Feb., 85...	5/0	— Def.......................	100	13
28 Mar.	3/0	Brazilian Submarine.........	10	12⅛
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	8⅞
12 April	2/6	Eastern	10	11⅝
12 April	3/0	— 6% Pref.	10	14¾x
1 Feb.	5%	— 5%, 1899	100	110
28 Oct.	4%	— 4% Deb. Stock	100	108¾
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	13⅛
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	101½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	6 1-16
12 April	3/0	— 6% Pref.	10	14
3 Jan.	5/0	Great Northern..............	10	15
1 Mar.	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	18
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	5¾
16 Mar.	5%	Maxim Weston	1	⅛
15 May	5%	Oriental Telephone	11	7/16
14 Oct.	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2⅝
15 Feb.	15½%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40½
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	14½
......	...	West African..................	10	5
1 Mar.	5%	— 5% Debs.	100	92½
29 Dec.........	6/0	West Coast of America ...	10	5¾
31 Dec.	8%	— 8% Debs.	100	117
14 Oct.	3/9	Western and Brazilian	15	9 13/16
14 Oct.	3/9	— Preferred	7½	6⅝
......	...	— Deferred..................	7½	3¾
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	10¾
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 Nov.	7%	West Union of U.S..........	$1,000	125
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. April 13 ...	£4,649	...
Cuba Submarine	M. of Mar. ...	3,800	+ £73
Direct Spanish.....................	M. of Feb. ...	1,900	+ 37
— United States	None	Published.	...
Eastern.............................	M. of Mar. ...	54,376	+ 4,579
Eastern Extension	M. of Mar. ...	£39,670	+ £1,493
Great Northern	M. of Mar. ...	22,000	...
Submarine	None	Published.	
West Coast of America	M. of Mar. ...	4,175	...
Western and Brazilian	W. April 13 ...	3,787	...
West India and Panama	F. April 15 ...	3,022	+ 649

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended April 20 amounted to £4,104.

St. James' and Pall Mall Electric Light Company.—The letters of allotment in the St. James' and Pall Mall Electric Light Company have been posted. Mr. James Hemmerde has joined the board of the Company.

United Telephone Company.—At a meeting of the Board of Directors of the United Telephone Company, held on Tuesday last, Mr. Frederick Richards Leyland was elected a Director of the Company, in the room of the late Mr. E. Dwyer Gray, M.P.

The Cable Companies' Dispute.—A telegram from Paris says:—"The court has reserved its decision as to the pending differences between the Anglo-American and French Cable Companies until the proper courts have decided with regard to the step taken by the Government respecting the French company, which was the origin of the lawsuit."

Eastern Extension, Australasia, and China Telegraph Company.—The Eastern Extension, Australasia, and China Telegraph Company announce that the coupon on their Five per Cent. Debentures (1880 issue), due on May 1 proximo, will be payable on and after that date, on presentation of the same at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons should be left three clear days for examination.

Reuter's Telegram Company.—The report of Reuter's Telegram Company, Limited, states that the net profits for the year ending the 31st December amounted to £4,242, including £187 brought forward. An interim dividend of 2½ per cent. was paid in October, and they now declare a further dividend of 2½ per cent., making a total distribution, tax free, of 5 per cent. for the year. After adding £500 to the reserve fund, £61 will be carried forward.

West India and Panama Telegraph Company.—The Directors of the West India and Panama Telegraph Company, Limited, owing to improvements of revenue derived from exceptional causes and some increase in the traffic, recommend a dividend of 10s. per share on account of arrears of dividend on the 1st preference shares. The estimated traffic receipts of this Company for the half-month ending *the 15th April are £3,022, as compared with £2,373 last year, showing an increase of £649.*

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the week ended April 20, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,390. The Directors of the Company, in their report for the year ended December 31, state that the total earnings amounted to £159,789, an increase of £21,123. The working expenses, exclusive of renewals of cable, were £64,316, as against £62,604. Including the amount brought forward, the revenue balance is £100,032, from which has to be deducted £27,000 for debenture interest, leaving £73,032, of which £15,000 has been placed to the renewal fund, and £10,000 to a debenture redemption fund. The Directors recommend a dividend of 3 per cent. tax free, which with the interim dividend of 1¼ per cent. paid on the 15th of October, makes a total of 4¼ per cent., leaving £3,464 to be carried forward. This will give to the preferred ordinary shares 5 per cent. for the year, will clear off 3s. 1½d., the amount in arrear upon these shares, and give 2s. 1½d. per share to the deferred ordinary shares. The undertakings of the Company and of the London Platino-Brazilian Company, Limited, are so closely allied that it has become desirable, in the opinion of the Board, that, so far as may be practicable, without effecting an actual amalgamation—as to which at present difficulties stand in the way—they should be brought under a common control, with a common proprietary; and, after long negotiations, arrangements have been made for this purpose. An agreement has, it is stated, been entered into by the Board of each company for the exchange by the shareholders of the Platino Company of their shares for shares of the Company at the rate of five shares of £10 of the Platino Company for three shares of £15 of the Company, and for the substitution of Directors and officers of the Company for those of the Platino Company, who will receive compensation as provided by the agreement. The capital which may be required for these purposes will not exceed 24,000 shares. The agreement, subject to confirmation by special resolutions of each company, and conditional upon three-fourths at least of the shareholders of the Platino Company exchanging their shares within fourteen days after such confirmation, or such extended period as may be agreed on, will be submitted for approval to the extraordinary general meeting, and, if approved, a further resolution will be proposed, authorising the increase of the capital to £1,500,000 for the purpose of enabling its fulfilment and for other purposes.

Bournemouth.—The question of giving sanction to the application of Messrs. Phillips, Harrison, and Hart to the Board of Trade for a license to supply electricity within the district came up again for consideration. The subject was adjourned from the last Board meeting. The Clerk said that since the last meeting of the Board he had received a draft of the proposed license. The document was of considerable size, and should be carefully considered in committee. He suggested that it be referred to a committee of the whole Board, and that the discussion of the question be further adjourned until the next Board meeting, and it was so adjourned.

The Cance Arc Lamp.—The new low-power lamps by the above-mentioned maker, taking from three to six amperes, and giving, when enclosed within ground-glass globes, a light of from 190 to about 240 candles, have attracted much attention at the exhibition of the French Physical Society. The light is as steady in the case of these small arcs as in the lamps taking seven or eight amperes, and the question of the distribution of the arc light thus appears to be very satisfactorily solved. As a contrast to these small lamps, M. Cance has just constructed two lamps taking from thirty to forty amperes, these vast sources of light being for the Bon Marché establishment.

Winterthur.—Progress is being made in various directions in electric lighting. The steamers "Helvetia" and "Thurgau" have been fitted with the electric light, and the North-Eastern Railways intend adopting it for all their steamers on the Lake of Constance. At the Hotel Engadiner Kulm at St. Moritz, 10 arc and about 700 glow lamps are installed. This lighting can be greatly extended, as only half of the water-power of 180 h.p. available is at present utilised. A scheme is also on foot for lighting the town of Interlaken electrically, and a commencement will be made by the erection of arc lamps in the Höheweges and the large hotel situated there.—*Industries.*

Accumulators.—Prof. Tito Martini publishes in a pamphlet of 19 pages, which he read to the Royal Institute of Science, Literature, and Art at Venice, his report on the various trials which he made with the accumulators of Montaud, Cannstall (Fabrik), Sellon-Volkmar, and Trevisian. The result of these trials was that the accumulators of Sellon-Volkmar, as supplied by the E.P.S., and those of Trevisian are much to be preferred to the other two types. It is specially noted of the Sellon-Volkmar type that it maintained its good reputation in every respect, and the Professor also speaks very highly of the less-known make of his countryman, and specially reports that this type distinguishes itself especially by the long life of the positive plates.

"Journal" of the Society.—The new part of the *Journal* of the Society of Telegraph-Engineers has just been issued, and contains the paper by Mr. R. von Fischer Treuenfeld upon the "Present State of Fire Telegraphy," and the discussion thereon; also the paper by Prof. Rücker, F.R.S., and C. V. Boys, A.R.S.M., "On the Optical Demonstration of Electrical Stress." We cannot help referring to a sentence of Prof. S. P. Thompson during the discussion on this latter paper, in which he refers to that excellent little book, by Mr. F. C. Webb, on "Electric Accumulation and Conduction." In our opinion this book ought to be re-edited and republished. It was not appreciated when originally written, because so much before its time, and had but a limited circulation. But to return to the *Journal.* The number concludes with a list of additions to the library, the society's balance-sheet, and the abstracts of foreign papers.

Isolated Electric Lighting in Towns.—Legal proceedings have been instituted against the managers of the Vaudeville Theatre and the Café Américain, in Paris, by the inhabitants of the houses adjacent to these two establishments. They complain not only that the courtyards of neighbouring houses are filled with smoke and blacks arising from the engines used to drive the dynamo machines, but also of the vibration produced by the engines in question. The object of the proceedings was to obtain the appointment of an expert to consider and to carry into effect the work necessary for abating the nuisance. This object, we are informed, has been attained in the appointment by the president of the referees of an electrical engineer, M. Fribourg, as the expert in question.

Electric Cricket Club.—At the annual dinner of the Cardiff Electric Cricket Club, Mr. Gavey, in responding to the toast of "The Service," spoke of the advancement and improvement in telegraphy generally, and especially in Cardiff. That town was rapidly growing, but the telegraphic service kept well in advance. As an instance of its progress, he said that two trunk lines were now to be laid down in order to connect Cardiff for the first time with Glasgow and Manchester, so that by the middle of next summer Cardiff would be in direct communication with the most important of the large manufacturing and commercial centres, and thus occupy as good a position as any town in the country. The toast of "The Electric Cricket Club" was given by Mr. S. Jones, and the captain (Mr. H. Evans) and secretary (Mr. Baxter) responded. Other toasts, songs, recitations, &c., folowed, and a convivial evening was spent. Why—oh, why! Mr. Albright, Mr. Stepney Rawson, and other athletic electricians, do we not get up a peripatetic cricket club for the London district.

Obituary.—Many members of the Society of Telegraph Engineers wondered at the last meeting to hear so high an eulogium from Capt. Douglas Galton upon one whom all who knew him regret to have lost, but whose name was not so familiar to the younger generation of electricians as it was to those who were pioneers in submarine telegraphy. The late T. R. Crampton was a friend of the old school, whose hand clasp was as warm as his heart was large. He was a genial companion, and cared more for honest friendship than for the fickle praise of sycophants. To his energy and ability the success of the cable from England to France was greatly due. The writer has often chatted with the veteran over those old days, information about which is so frequently incorrect. But Mr. Crampton made a name in directions other than telegraphy, and is better known to the world, perhaps, in connection with his railway work than in any other. His presence will be greatly missed by a select circle which used to be merry at each return of the meeting of the British Association.

Traction in Mills.—At the Tremont and Suffolk Mills, Lowell, Mass., an installation of Thomson-Houston electric motor cars, for hauling the bales of cotton, &c., has been working very successfully for some months. The motor is mounted on a specially constructed car, the current being conducted by a single overhead line, returning by the rails The motor will draw four tons; the rails are 4ft. 8½in. gauge and extend for 800ft., running the full length of two buildings and up an incline across a bridge. It is furnished with a

reversing switch, speed regulator, and brake handle, and has acted with so much satisfaction that the mill-owners contemplate considerable extension, and the Thomson-Houston Electric Company are understood to be preparing for considerable work in this direction. For large mills, with their long lines of flooring, a small platform car, running throughout their length on narrow gauge rails to distribute or gather the material, is capable of very general adoption, and it is said by the mill-owners to be one of the most convenient mechanical arrangements they have about their whole mill.

Indian Telegraph Service.—Mr. Conybeare asked the Under-Secretary of State for India, on Tuesday, what had been the result of the special inducements to retire offered to the officers in the blocked years of the Indian Telegraph service; whether such inducements had had the desired effect, and, if not, what was the cause of failure; whether it was the fact that promotions in the telegraph service were now made only twice a year; whether the effect of this arrangement was to inflict a loss of, perhaps, several months' pay and promotion in the case of those who were moved up into vacancies in the intervals between the biennial promotion days; and whether such a rule was in force in any other branch of the public service. Sir J. Gorst answered that the first period at which retirement might have taken place was March 31. No intimation as to the result has yet been received. Permanent promotions are now only made twice a year, but acting promotions are made as vacancies occur. The full pay of the higher rank is not attained until the permanent appointment is made. Meantime an acting allowance is received. No such rule is in force in other departments of the public service.

Transmission of Energy in Spain.—A company in Valencia has obtained a concession for the distribution over a distance of 35 miles of motive power, to the extent of 3,000 to 4,000 h.p., which is to supply the requirements of the town and its neighbourhood. The company in question is in negotiation with several English firms relative to the execution of this undertaking. The Turia river, from which power is initially to be obtained, supplies about 10 cubic metres of water per sec., and has a fall of 32·4 metres at the point where the supply is to be utilised. The expense of developing the motive power is estimated as follows:—

Interest at 5 per cent. on an initial capital of 3,327,800fr.	166,387fr.
Amortisation in 20 years of flood gates, sluices, &c.—say 5 per cent. on 176,675fr.	8,850 ,,
Amortisation in 20 years of the electrical apparatus—say 5 per cent. on 840,350fr.	42,025 ,,
Amortisation in 50 years of the electric line and its accessories—say 2 per cent. on 960,950fr.	19,225 ,,
Maintenance of hydraulic machines	(?) Memoir
Maintenance of electrical apparatus at the rate 2 per cent. on 1,801,325fr.	36,026fr.
Total	277,826fr.

Rouen.—This capital of the Seine Inférieure appears to be leaving the capital of France far in the background. Besides the work done by its central lighting station, several considerable installations have recently been carried out. A waterfall situated about 1,500 metres from the works of M. Giron has been utilised for the production of electric power; and the Thomson-Houston Company have installed nine arc lamps, each of 1,200 c.p., at these works. A current from the same source illuminates several large greenhouses belonging to M. F. Richard, horticulturist, at Rouen; and the effect of the light upon vegetation is therein being investigated by the Rouen Horticultural Society, who intend to issue a report on this question. The office of the *Patriote de Normandie* is being fitted with 35 incandescence lamps, supplied by a small Thomson-Houston machine, worked by a gas-motor; the lighting being safeguarded by means of an accumulator. Negotiations are in progress with reference to the lighting of the church of St. Ouen, on the Place de l'Hotel de Ville, by means of 100 arc and 350 incandescence lamps; the motive power being supplied by steam engines at a distance of three kilometres from the church. Applications have been made to the Municipal Council for authority to light the theatre and several public establishments.

The Ader Signalling System.—According to the *Bulletin de l'Electricité*, the experiments made on the system of signalling by means of telephones through long submarine cables justify the expectation that the speed of signalling through such cables may be increased by this means. This would of course render M. Ader's invention of practical importance—perhaps of very considerable importance—in submarine telegraphy. The system in question is very simple, and is at least of interest from an abstract point of view. At the receiving station the cable divides into two branches, each of which passes to earth through a telephone and a local battery. The two batteries have opposite poles connected to the cable, and are of such strength that one or the other of them nearly neutralises an arrival current in a given direction, whilst reinforcing an arrival current in the opposite direction. By means of an interruptor connected to each telephone, the instruments are caused to emit a different note when traversed by a current. Thus a positive arrival current sounds the note *sol*, for instance, in one of the telephones; whilst the other remains mute or nearly so, whilst a negative arrival current will sound *do* in the other instrument. The system is probably already familiar to many of our readers; but to others it may be rendered intelligible by the above brief description.

Telegraph Clerks.—Viscount Curzon on Monday asked the Postmaster-General whether in October and February last clerks at the Central Telegraph Station were promoted from the second to the first class three years before they reached the maximum of their class; whether clerks of from 17 to 19 years' service had been waiting at the maximum of the first class for 13 months; and whether there was anything against the ability or character of these clerks, and, if not, why this partiality was shown to one class. In reply, it was stated that the facts set forth in the question were substantially correct. In the one case there were vacancies at the time on the higher class, whereas in the present case there are no vacancies, and consequently no promotions can be made. In answer to Mr. Carew, Mr. Raikes also said: On the acquisition of the telegraphs by the State, the reason for subjecting the telegraphists at the Central Station to a deduction during absence from illness was that they might not be subject to different rules from those which applied to Post Office servants of similar grade. These rules have been considered again and again, and I am not prepared to alter them. Full pay during absence is confined, as a rule, to those who occupy the more responsible positions. The officers of the intelligence branch are picked men, selected from the whole body of telegraphists throughout the kingdom.

The Electric Light in Italy.—In the report presented by the Administrative Council to the general meeting of the Edison Company in Milan, the increase of joint stock enterprise is pointed out. At the end of last December the installations already carried out comprised 11,010 incandescence and 218 arc lamps—that is to say, 1,470 incandescence and 64 arc lamps over and above the number that had been installed in December, 1886. The receipts amounted to 564,622.27 lires, showing an increase of 161,728.84 lires over the preceding year, whilst, on the other hand, the expenses have increased during the same period only by 63,307.28 lires. The number of isolated installations has very much increased, the most important of these carried out in 1887 being those of the San Carlo and Sannazzaro theatres of Naples. The result of the proceedings of the gas companies against the Municipality of Milan has given a fresh stimulus to the electrical industry. For the information of some of our readers, we may state that this result was that the court rejected the application of the gas company, and authorised the municipality to install electric lighting in the streets. It is true that competition on the part of gas is still prevalent; but this judicial decision has had the effect of reducing it. Moreover, there is plenty of room in Milan to allow of the two systems subsisting together side by side.

Shakespeare and Electricity.—The same year which saw the publication of Gilbert's work on electricity witnessed also the appearance of Shakespeare's plays of "Hamlet" and "Much Ado About Nothing." That Shakespeare had considerable knowledge of atmospheric phenomena now, but of course not then, known to be electrical, is apparent from many instances. Witness Prospero's

"to the dread rattling thunder
Have I given fire and rifted Jove's stout oak
With his own bolt."

Or Ariel's self description in the guise of St. Elmo's fire:

"Sometimes I'd divide
And burn in many places: on the topmast,
The yards, and bowsprit would I flame distinctly,
Then meet and join.

There are but two passages, so far as I have been able to discover, in which the poet makes reference to the attraction of iron. The first is in "Midsummer Night's Dream" (act ii., scene 2):

"You draw me, you hard-hearted adamant,
But yet you draw not iron, for my heart
Is true as steel. Leave you your power to draw,
And I shall have no power to follow you."

The second is in "Troilus and Cressida" (act iii., scene 2):

"........... truth tir'd with iteration
As true as steel, as plantage to the moon,
As sun to-day, as turtle to her mate,
As iron to adamant."

Park Benjamin in April "Forum."

Writing Telegraphs.—In the House of Commons the other day Mr. M'Ewan asked whether the Postmaster-General's refusal to grant a licence to the proprietors of the Writing Telegraph was indicative of a resolution to depart from the position taken up by the Government, as defined by Sir Henry James (then Attorney-General) on the 15th of December, 1880, in the case of "The Attorney-General *v.* United Telephone Company," as follows:—"There is no desire on the part of the Crown to check invention. I most emphatically disclaim that. Inventors and companies will always be dealt with in a liberal spirit if they consent to become licensees of the Crown"; and, seeing that the proprietors of the Writing Telegraph only wished to become licensees of the Crown, why should they be treated differently from other companies using telegraph systems? Sir H. Maxwell replied that the Postmaster-General had not succeeded in finding a record of the statement attributed to the right hon. member for Bury. The arguments in the case of "The Attorney-General *v.* the Edison Telephone Company" (it was not the United Telephone Company) were concluded on the 3rd of December, 1880. Judgment was given on the 20th, and there were no proceedings in Court on the 15th. In the absence of more specific information, therefore, he was not able to follow the hon. member in his reference. He observed, however, that the Telegraph Act of 1869 leaves it to the Postmaster-General's discretion whether a licence shall or shall not be granted to a person or company proposing to transmit telegrams, and the Government have never assumed the position of granting indiscriminately a licence to every inventor of a new form of apparatus.

Hamburg.—The electric light installation of the Free Port and Docks of Hamburgh will comprise, when finished, 50 arc lamps of 10 amperes, and about 4,000 16 candle-power incandescent lamps. The arc lamps are grouped in series of 10, and each circuit is fed by its own dynamo. The incandescent lamps are in multiple, and divided into a number of circuits, the current for which can be arranged from the switch-board in the dynamo room. The motive power for the incandescent circuit is obtained by three pairs of compound engines, each of 220 horse-power nominal. Two of these engines are already in place; the high-pressure cylinder is 40 centimetres in diameter with 80 stroke, and the low pressure 60 centimetres in diameter with the same stroke. The engines run at 100 revolutions per minute. There will be six dynamos for the arc lamps—five usually working and one held in reserve—driven by a single cylinder non-condensing engine, with a cylinder 362mm. in diameter, and having 724mm. stroke. The engine will make 90 revolutions per minute. The leads will be carried in rectangular iron pipe conduits underground. The power is transmitted from the engine by means of belts and countershafts. Six 8-pole Schuckert machines, making 350 revolutions per minute, will furnish a maximum current of 400 amperes under a pressure of 120 volts for the incandescent lighting. The current from the machine is laid to a distributing board; an ammeter is placed in the circuit of each dynamo and in each exterior circuit, of which there are eight actually laid. The voltage is regulated by an automatic regulator, and the state of the lamps at various points of the circuit is shown by guide lamps in the engine-room, fed by means of wires brought back from selected points of the principal circuits. When the machines are coupled in parallel, a resistance is used to obtain the same voltage at the terminals of the machine. The pressure at the lamp terminals is obtained by interposing more or less resistance in the service mains. This operation is effected automatically by means of electro-magnets and resistance coils in each of the principal circuits. The commutator of this resistance coil is composed of a cylinder with metallic bars of unequal length, which automatically make contact, and thus interpose in the circuit a greater or less number of coils of German silver. In addition to the ammeters, voltmeters are also used, and the total consumption is registered by Aron-Coloumb meters.

Southampton.—It appears likely that Southampton will shortly have an opportunity of testing the capabilities of electricity; at present in the shape of the electric light, though, having regard to the wide field for operation in the town, it is not improbable that the current will, in the

future, be adopted for other purposes than that of lighting. In the first place, we have the Southampton Electric Light and Power Company, which has been registered with a capital of £30,000 in £5 shares, "to carry on the business of electricians, mechanical engineers and manufacturers, and workers and dealers in electricity, motive power, and light." It is proposed to start with 1,000 glow lamps and plant sufficient to work them. These lamps will be chiefly used in the shops and other places of business in the district surrounding the central station. The system to be used and the method of distribution have yet to be decided on. The station will be situated in the High-street, on premises in an excellent position for the purpose, and containing ample accommodation for the plant both for the present work and for future extensions. The first subscribers to the Company are all residents in or near the town, and are intimately connected with it. The undertaking is favourably regarded by many of the leading tradesmen; and with all these things in its favour the Company should be a success. At a meeting of the Town Council on the 25th ult., the Special and General Works Committee reported that they had again considered the report of the borough surveyor (Mr. Bennett) as to the cost of lighting by electricity the Audit House, the Guildhall, and the Hartley Institution, as well as the Corporation Wharf at Chapel, and certain streets in its neighbourhood, and recommended the adoption of the report. It is intended to utilise the heat from the refuse-destructor at the Corporation Wharf for generating the current. The dynamos will charge a set of accumulators, and from these the lamps will be lit. The present cost of lighting the above-named places by gas, including the church clock of Holyrood, and a Sugg's lamp near the church, is £378. 10s., whilst the electric light is estimated to cost £207. 10s., thus showing a balance of £171 in favour of electricity. This large saving is due to the fact that there is no cost for fuel, as the burning refuse in the destructor supplies the heat. The estimated cost of the work is £1,440, for which it is intended to invite tenders. It is thus probable that Southampton folks may shortly be in a position to appreciate the value of electric lighting.

Price of Gas.—It is often interesting to electrical engineers to know the price of gas in any district. The following table (taken from an Aberdeen paper) gives such prices, and the number of consumers for various towns:—

Population.	Town.	Illuminating power in candles.	Price per 1000 cubic feet. s.	d.	No. of consumers.
30,000	Aberdeen	15	4	3	744
12,300	Altrincham	19	3	3	2,300
22,000	Arbroath	27	4	1½	5,041
37,000	Ashton-under-Lyne	19	2	4	8,668
31,500	Barnsley	18	2	6	3,900
50,000	Barrow-in-Furness	20	3	6	2,466
30,000	Batley	17	3	0	5,200
5,000	Beccles	14	4	5	337
22,000	Bilston	16	2	10	2,100
28,000	Bournemouth	15½	3	10	1,850
15,000	Bromley	15	3	10	2,500
3,800	Bungay	16	5	0	230
26,000	Burslem	16	3	0	3,120
42,000	Burton on-Trent	18	3	0	3,600
16,000	Bury St. Edmund's	16	3	6	1,000
40,000	Cambridge	17	3	0	—
22,000	Canterbury	16	2	7	2,100
38,000	Carlisle	19	2	6	5,600
—	Chelmsford	14	4	7	860
37,000	Chester	17	3	4	3,000
12,000	Chesterfield	16	3	3	1,522
23,000	Clayton	16	3	4	2,662
25,000	Coatbridge	26	3	9	4,500
30,000	Colchester	16	3	9	1,280
47,000	Coventry	17½	3	0	5,000
35,000	Darlington	16½	2	1	3,100
35,000	Darwen	18	3	3	400
50,000	Devonport	15	2	6	3,000
33,000	Dewsbury	18½	3	0	6,500
22,000	Doncaster	18	2	11	2,600
30,000	Dover	15	3	0	2,212
47,000	Dudley	15½	3	0	2,200
21,000	Dumfries	27	3	9	3,000
38,000	Exeter	14	3	3	3,650
38,000	Gloucester	18	2	7	2,800
23,000	Gravesend	17	3	4	2,500
36,000	Great Grimsby	14	2	11	3,329
46,000	Great Yarmouth	12	3	2	2,600
48,000	Hanley	15	3	0	5,200
50,000	Hartlepools (The)	15	2	6	3,500
16,000	Haslingden	18	3	9	1,600
21,000	Harwich	14	5	0	320
23,000	Heywood	18	3	3	4,118
56,000	Ipswich	16	3	2	3,000
50,000	Keighley	18	2	6	7,650
26,000	Kilmarnock	27	3	11½	5,000
20,000	Kingston-on-Thames	16	3	2	4,000
20,000	King's Lynn	14	3	6	1,500
24,000	Kirkcaldy	28	3	4	6,000
26,000	Kirkcudbright	28	7	1	290
23,000	Lancaster	20	2	10	—
23,000	Leamington	17	2	6	3,200
25,000	Leigh	18	2	11	1,600
38,000	Lincoln	17	2	8	5,500
32,000	Longton	15½	3	0	2,500
25,000	Longwood	18	2	9	2,300
25,000	Lowestoft	14	4	4	932
31,000	Luton	17	2	8	3,000
40,000	Macclesfield	19	3	0	3,500
30,000	Maidstone	16	2	6	2,500
55,000	Merthyr Tydvil	16	3	2	1,180
45,000	Mitcham	15	4	0	2,050
20,000	Nelson-in-Marsden	17	2	7½	4,500
18,000	Newcastle (Staffs)	16	3	0	1,600
90,000	Norwich	14¾	3	4	6,288
26,000	Oldbury	16	2	9	2,000
36,000	Over Darwen	17	—		5,300
44,000	Oxford	16	2	8	4,134
30,000	Perth	29	3	9	7,300
21,000	Peterborough	17	3	4	1,600
24,000	Pondersend	15	4	6	900
12,000	Pudsey	16	3	4	3,500
40,000	Radcliffe	18	3	6	3,500
23,000	Ramsgate	16	2	10	2,500
22,000	Richmond, Surrey	15	3	4	2,625
36,000	Rotherham	16	2	9	2,969
33,000	Scarborough	17	3	0	3,852
26,000	Shrewsbury	15	3	0	3,550
25,000	Smethwick	17	2	6	2,000
37,000	Southport	21	3	0	6,869
30,000	Sowerby Bridge	19	3	4	—
27,000	Staleybridge	16	3	2	4,200
25,000	Stoke-on-Trent	16	2	3	2,000
37,000	Stourbridge	15	2	10	1,300
48,000	Stroud	16	3	4	1,150
30,000	Tipton	17	2	3	2,000
25,000	Torquay	16	3	6	2,340
25,000	Tunbridge Wells	15	3	6	2,400
47,000	Tynemouth	14	2	3	2,400
32,000	Wakefield	17½	2	6	5,000
21,000	Wallasey	20	3	0	2,880
45,000	Warrington	18	2	6	—
25,000	Widnes	17	2	0	—
42,000	Worcester	18	2	10	3,300
22,000	Workington	18	2	11	1,400

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 296.*)

THE MEASUREMENT OF LOW RESISTANCES.

The measurement of the resistance of conductors used for the mains or principal branches of electric light leads, the armature coils of low-resistance dynamos, and other purposes of a similar kind, has become of considerable importance, and I propose to consider one or two of the most convenient methods of proceeding. When the resistance is not very low, the measurement may be made with sufficient accuracy by means of a box of conductances such as that shown in Fig. 7, p. 199 above. The conductance box is in this case used as one side of the Wheatstone's bridge, the wire under test forming another, while the other two sides, or the divided resistance, as it is often called, may very conveniently be the wire of one of the forms of Kirchoff bridge already figured and described (Figs. 11 and 12, p. 247). The greatest difficulty, perhaps, in the application of this method is in the elimination of the resistance of the contacts and the wires required to connect the test piece, or coil, into the bridge. Take, for example, the armature of a dynamo. It is impossible to put the commutator, or brush rings, directly into the binding screws or mercury cups of the bridge, and hence connecting wires have to be used. Now, the resistance of these, even when so thick as to be inconvenient for handling, may be equal to quite a large fraction of that of the coil being tested, and hence a second test of the resistance of these connections is required in order to eliminate them from the result. There is, besides, a liability to large percentage errors, due to resistance in the multiplicity of contacts introduced. In such cases one or other of the following methods will be found preferable :—

1. *Series Circuit Potential Method.*—In this method the test piece, or coil, the resistance of which is required, is joined in series with a standard bar of suitable resistance in the manner shown in Fig. 18. Referring to this figure,

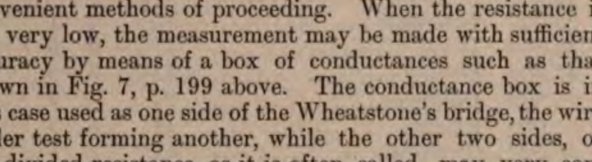


FIG. 18.

w represents the standard bar, which we will suppose mounted on a board on which there are also fixed a mercury trough, C, and a reversing key, K. The key, K, may be of any convenient form, but for the testing of specimens of thick conductors it is convenient to make it of four cups of mercury arranged at the four corners of a square, the ends of the wires, w and w_1, being placed in the cups at the opposite ends of one diagonal of the square, and the two electrodes of the battery in the cups at the ends of the other diagonal. The current can then be sent through the circuit in either direction by means of two copper U's of width equal to the side of the square. The standards, w, should either be of uniform resistance along their length, or they should be calibrated and provided with a scale, so that the resistance between any two points of their length can be readily calculated. Suppose, in the first place, that the resistance per yard or per metre of a thick copper conductor is to be measured. Put one end of a specimen of the conductor into the mercury cup, C, and connect the other end to one of the terminals or mercury cups of the key, K. Close the circuit through the battery, B; putting a resistance in the battery electrodes, should the current be too strong for the battery to maintain steadily. Now place the terminals of the electrodes of a sensitive galvanometer, G, of moderate resistance, in contact with two points a and b, and note the deflection produced. Next find two points c and d on the standard bar, at which, when the terminals of G are put in contact with the bar, the same deflection is produced. If there is no thermo-electric effect on the galvanometer—due, for example, to difference of temperature and difference of thermo-electric quality of the conductor between the points a and b or c and d—the resistance of the part of the conductor between the points a and b will be equal to the resistance of the part of the standard bar included between c and d. This conclusion follows at once from Ohm's law and the fact that the same current is flowing in both conductors. In order to avoid chance of error due to thermo-electric effect, the current should be reversed and the experiment repeated. The arithmetic mean of the results will give the true length of the standard bar which is equivalent to the length $a\ b$ of the conductor under test. From the length of the conductor between a and b, and the known resistance of the standard bar, the resistance per unit length of the conductor can be calculated from the equation: Resistance per unit length $= \dfrac{\text{Resistance of } c\,d}{\text{length of } a\,b}$. The galvanometer used for this test must have considerable sensibility, because with even a strong current flowing through a thick rod of copper only a yard or two long, the difference of potential between the points a and b will be small. A mirror galvanometer is most suitable, but any galvanometer having the requisite sensibility will do; it should have such a resistance that the current flowing through it is a small fraction of the current in the circuit. It should be observed, however, that this does not, as a rule, imply that the galvanometer should be a high resistance one in the ordinary sense. Quite the contrary is the case, as a high resistance galvanometer is never sensitive to small E.M.F. at its terminals; and a galvanometer of one ohm, or even a tenth of an ohm, resistance, will not, when used in this way, take a sensible fraction of the current flowing through a copper conductor of half a square inch, or more, cross section. There is, of course, no error introduced, even if the galvanometer takes a sensible fraction of the whole current, if equal deflections are obtained for the resistance between $a\,b$ and $c\,d$; because, in that case, the shunting action of the galvanometer is equal for both deflections. If, however, different deflections are used, and the length of the standard which is equivalent to $a\ b$ estimated from the relative deflections, the relative currents in the main and the galvanometer circuits must be known when the galvanometer current is strong. When a sensitive galvanometer is used, there is generally a slight change of zero when its terminals are joined. The reading obtained when the ends of the electrodes are in contact should be taken as the zero of deflection.

An important modification of this method will, no doubt, occur to most readers—that is, the use of a differential galvanometer instead of G. This has the great advantage of making the method a zero deflection one, and this in almost all cases conduces to accuracy and increase of sensibility. When a differential galvanometer of suitable resistance is available, the electrodes of one coil are placed in contact with two points, a and b, and the electrodes of the other coil are then adjusted to two points, c and d, such that no deflection is produced. In the use of this method the coils of the galvanometer should not be arranged to have a common terminal, because in that case part of the circuit would be shunted through that terminal, and the result would be disturbed by contact resistances.

As another example, we may consider the case of the measurement of the resistance of the coils of a dynamo armature. Take a Gramme ring for example. Place the board carrying the standard rod, w, the key, K, and the mercury trough, C, in a convenient position near the dynamo, and carry thick connecting pieces from the dynamo terminals to K and C. Pass a current from a battery through the circuit, and find the deflection on the galvanometer, g, produced by putting its terminals in contact with the same commutator bars that are touched by the brushes. Next find the equivalent length of the standard bar as before. The experiment is in this case precisely similar to that already fully described, with the exception that connecting wires have to be introduced from the dynamo terminals to the testing board. The resistance of these leading wires in no way enters into the test, and hence no inconvenience is introduced by their use. It should be particularly noticed

e contacts of the galvanometer terminals are to be rect to the commutator bars, and not to the brushes, the resistance of the brush contacts do not enter. plication of this method to the investigation of the f motion on the contact resistance of brushes is and will be referred to further on.

rallel-Circuit Potential Method.—A very convenient ment for tests such as we are now considering, as several other tests which we will have to consider shown in Fig. 19. A heavy copper bar, A, furnished terminal screw, or a mercury cup, T, forms the terminal of a set of conductances, which are here n the form of spirals of wire. These conductances ke any form which is convenient in the circum- and where the size of the apparatus is a matter of nce, perhaps the best form is simply a set of straight platinoid, say, an eighth of an inch in diameter and , soldered to the bar, A, at one end, and fitted at the ith thick copper terminals, which can be dipped into rcury trough, C. These conductances should be equal, both in dimensions and in conductance, so ien any number of them are joined in parallel, the same current will flow through each, even if the be so strong as to heat them considerably. A mercury C, and cup, D, are arranged on the same board with A, position that the terminals of all the conductances can be placed in C, while the terminal of that one ut into D. The trough, C, and the cup, D, should e made of copper, or have copper bottoms, which, ase of C, must be so thick that its conductance is a thousand times that of one of the platinoid rods. other end of the board two copper blocks, in which ed the cups E and F, are fixed. To the former, of a wire (w_2) is fixed, and the latter is in metallic

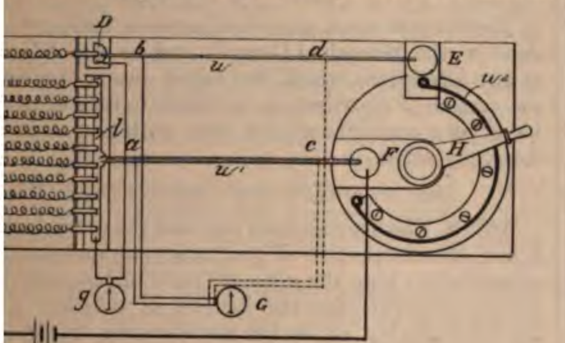


FIG. 19

with the lever H, which slides along w_2. When aratus is in use for the determination of the con- of specimens of conductors, the coils of dynamo es, the secondary coils of transformers, &c., the e is placed in the position shown by w_1, between C nd the standard conductance, w, between D and E. le low resistance battery is then joined between F nd a sensitive galvanoscope, g, between C and D. the conductances is then introduced between A nd such a number of the others between A and C, turning the lever H into contact with some part of w_2, the current through g can be reduced to zero. is is the case, the current through the standard w current through w_1, in the same ratio as unity is to ber of conductances between A and C. The current g is kept at zero by adjusting the position of the if necessary, and two pairs of points, a and b, and c w_1 and w, found by means of another galvanoscope, are at the same potential. The conductance of of the rod w_1, between the points a and c is then the conductance of the standard between c and d, ed by the number of conductances introduced in the etween A and C. This method has the advantage a zero method, and, also, that standards of moderate ns can be used for the measurement of the con- s of very thick conductors; and when the conduc- etween A and C are carefully adjusted to equality one between A and D, a high degree of accuracy is le. It is evident that any coil or circuit may be put in place of w_1, the connecting wires being put to C and F, while a and c are taken at the ends or any other part of the circuit. The same remarks that were made with regard to method (1) as to the applicability of a differential galvanometer in place of G apply in this case, but since the method is itself a zero one, the advantage is not very great. When a differential galvanometer is used, the two ends of one coil may either be put in contact with two points on one wire, and the terminals of the other coil adjusted on the other wire, until no deflection is obtained, or the terminals of one coil may be put to a and b, and those of the other coil to c and d, in which case it is immaterial whether the effect on each coil is zero, or the resultant on both is zero, providing, in the latter case, the proper terminals are put in contact with w and w_1. In order to avoid error due to thermo-electric potential in the circuit, the experiment should, as in method (1), be repeated with the direction of the current reversed. The degree of accuracy with which, when proper appliances are available, the measurement of the conductance of thick rods or tubes can be made by the methods just described, depends mainly on accuracy with which the lengths $a\ c$ and $b\ d$ can be determined. The conductance of even a foot of copper rod a square inch or more in cross section may be measured with almost perfect accuracy. The subject will be further considered in a continuation of this article.

ELECTRIC LIGHTING.

Proposed conditions under which electric light wires may be laid in the streets of Paris :—

CHAP. I.

ESTABLISHMENT AND MAINTENANCE OF DISTRIBUTING SYSTEM.

Object of the Conditions of Contract.

ART. 1. M. ———, living at ——— (or the company, the offices of which are at ———), is authorised to lay under ground, under the roads or the footpaths in the thoroughfares indicated in the annexed table, the wires or cables intended for the transmission of electric currents for the production of light, or for the transmission of motive power, and to execute, under the superintendence of the Administration, all the works necessary for distribution.

Installation of Wires or Cables.

ART. 2. The wires or cables may not be placed in the drainage galleries or underground ways beneath Paris.

They shall be laid beneath the footways in conduits of earthenware, of masonry, of metal, or any substance possessed of sufficient strength, and authorised by the Municipal Council after instructions from the Administration.

The position, the depth, and the maximum external diameter of these conduits shall in each case be fixed by the Administration, which will take into account, in arriving at its determination, not only the distributions already laid out beneath the same footway, but also, and more especially, those which it might reserve for establishment by itself in future for municipal purposes, it being understood that electrical distribution for the municipal service shall be the nearest to the surface of the ground. The licensee will not be permitted to bring forward any complaint by reason of a refusal to authorise the passage through certain streets on account of want of space beneath the footpaths under the conditions pointed out below, or on account of municipal reservations.

The wires or cables shall be placed under the roadways only for the purpose of crossings. These crossings shall be effected at a depth of at least one metre.

A distributing-main shall be established under each footpath adjacent to the premises to be supplied, so that the house branches may never cross the roads.

The only exception to this rule shall be for ways of which the breadth is considered by the Municipal Council to be insufficient.

Examination-boxes shall be established at certain distances, to allow of the inspection of the mains; and these shall be so arranged that, in case of breakdown, it shall be

possible, by utilising the examination-boxes, to withdraw and to replace the wires without opening the roads. The localisation and the arrangement of these examination-boxes shall in other respects be established by the Administration. In all cases they are to be closed with bituminised covers.

The examination-boxes shall be obligatory at one of the extremities of each of the crossings under the roadway of the cables. In the case of crossings beneath broad or frequented ways, and particularly when the roadway has a foundation of concrete, an examination-box must be established at each end of the crossings, and the Administration may, in addition, provide that these examination-boxes should be connected by galleries of a type to be indicated by the committee, which galleries shall in no case be in communication with the drains or with the private branches therefrom.

If a drain should be in the way of a gallery, the cable is to be taken over the drain.

In the case where several companies might be authorised to establish conductors beneath the same footway, the cables of these different companies may be placed in a common conduit constructed at a common expense, and of which the dimensions and mode of establishment must be approved by the Municipal Council.

Reservation relative to the Installation of Wires or Cables.

ART. 3. The wires or the cables may be laid only at a minimum distance of one metre from the frontages of the houses, the position there within being reserved for the municipal electrical network, and when the Administration, after the consideration of the matter by the Municipal Council, shall have ascertained—

1. That the position is suitable.
2. That the wires or cables, taking into account the strength of the current and the arrangement of the insulating envelope, may be placed there without danger to individuals and without inconvenience to the public service.

The reservation of one metre mentioned above, may be reduced by the Municipal Council in the case of ways in which it has been ascertained that the breadth of the footway is insufficient.

The Administration reserves in all cases the right to cause the licensee to remove his system of mains at a given period, either by reason of inconvenience caused by it, or simply in order to allow of new installations for the public service.

In default of the licensee carrying out this removal within the period allowed, he is liable to a fine of 50f. per day over time and per kilometre, or fraction of a kilometre, of main not so removed, without prejudice to the carrying out of the removal by the Administration itself. The licensee will be authorized in such cases to restore his system of mains under conditions to be laid down by the Administration, with the approval of the Municipal Council, as in all cases when a modification of the system of mains may be in question.

House Branches.

ART. 4. The wires leading into premises shall, between the principal cable and the frontage, be laid in conduits in connection with those of the main cable.

All portions of the installation other than the branch wires, such as cut-outs, &c., shall be established beyond the limits of the public way.

Transformers.

ART. 5. If the use be made of transformers, these are to be installed outside the public way.

Description of the Purposes of Distribution.

ART. 6. Prior to the commencement of the carrying out of any portion of the distributing system in the public ways, the plans upon which it is based shall be laid before the Municipal Council and the Administration, five copies of such plans being supplied by the licensee, who is not authorised to commence the work until after the notification of the reception of these plans. In drawing up the latter, one may have access at the offices of the engineers to all the materials at the disposal of the Administration in relation to the conduits for water, and gas, or any other distributing system already authorised, of the drains and the private branches therefrom, of the existing or projected levels, &c.; but in no case can he have recourse against the Administration by reason of mistakes, imperfections, or omissions in the documents placed at his disposal, nor by reason of material obstacles which may happen in carrying out the work.

Access to Plans of Distribution.

ART. 7. The licensee will always keep open to access a plan on the scale of $\frac{1}{1000}$, of the network of distribution. Each house-branch shall thereon be indicated, with the number and the description of the lamps maintained in action, or a statement in horse-power of the motive-power conveyed. This plan shall be supplemented by every information as to the destination and the constitution of the cables, the nature, the dimensions, and the position of the conduits, &c. Detailed sections, on a scale of from ·02 to ·05, are to indicate any special arrangements adopted at any given point of the network, more especially at the crossing of drains, branch-pipes for water or gas, as well as at the crossings of roads.

Four copies of this plan are to be supplied, which are to be divided and brought up to date every six months.

Preliminary Notice of the Execution of Works.

ART. 8. Three days prior to the commencing of any work of canalisation, the licensee must give notice of it to the engineers of the municipal service. The same is to apply to all works of maintenance and repairs of the system of distribution, except in relation to researches in case of accident, notice of which may be given on the day when the search is proceeded with.

Additional Paragraph.

The licensee must give simultaneous notice to the President of the Municipal Council and to the Administration of any alterations which he might intend to carry out in the system of distribution, or which in case of urgency may have been carried out by him with the consent of the Administration.

Recovery of the Cost of Restoring Public Work.

ART. 9. The licensee shall pay into the municipal counting-house, after inspection of quarterly reimbursement accounts submitted to him, the ultimate costs of restoring the public way consequent upon the opening of trenches whether for the initial laying, or for the maintenance, or, lastly, for the removal of the conduits. These expenses will be based upon fixed prices, as follows:—

Square metre of paved roadway	5	francs.
" " " stonework	3	"
" " " asphalte pavement	18	"
" " " wood "	23	"
" " " bitumenous flag	8	"
" " " granite "	5	"
Each piece of granite coping, straight or curved..	1	"

Immediately on the execution of any work, and until its final acceptance, the licensee must restore and maintain a provisional means of passage over the trenches opened by him, provided always that this maintenance at his expense shall not be prolonged beyond fifteen days after the embanking in each street.

All restorations of public works necessitated by the establishment of the system of distribution, and not included in the above descriptions, shall be recovered on the presentation of accounts made out in accordance with the verified expenditure.

Observance of Administrative Regulations.

ART. 10. The licensee will be bound in carrying out works to conform to the regulations of the municipal services in connection with the technical direction of the public roads and walks, or of water and sanitary arrangements. The licensee will, moreover, be bound generally, not only in establishing but in working the distributing system, by all the regulations and orders which are actually in force and which become applicable within the period of the authorisation.

(To be continued.)

THE POLICY OF GAS COMPANIES AS TO INCANDESCENT ELECTRIC LIGHTING.*

In regard to the policy of gas companies as to incandescent electric lighting, the general inquiry for information is evidence enough of the importance of the subject. We hear on all sides the questions: (1) What effect will the introduction of an incandescent plant have on our business? (2) What amount of capital does it take to put in such a plant? (3) Can they sell light as cheap as we, and make money? (4) Are gas companies any more favourably situated for furnishing electricity than anybody else?

At the meeting of the association held in Dayton a year ago, you listened to two papers—one entitled "Gas and Electricity: Two Interests or One?" in which the operation of the gas and electric light business, separately and collectively, was discussed; the second having for a subject, "Gas with Electricity," in which the results of a year's experience in running gas and arc light plants collectively were given, accompanied with many practical suggestions of much value to those who had the introduction of an arc plant under consideration. In fact, the ground was so completely gone over that there is very little room left for saying anything new. However, the enormous sales of incandescent electric apparatus during the last year, together with the rapid improvement in the modes of generating and distributing the current, have added much that is of interest on the subject. We hear wonderful stories of a new system whereby the amount of necessary first investment in distributing plant is divided by ten, and at the same time the loss incident to distribution is reduced from 10 per cent. at a distance of half a mile to 2½ per cent., and no consideration whatever shown to distance. Verily, they sound like fairy tales. We might well ask, "Where is it to stop?" It would seem that the limits in these directions had well-nigh been reached.

It is, I believe, very generally conceded that, for some purposes, the arc light is far superior to gas. It has been frequently stated that the introduction of arc lights is accompanied by an increased consumption of gas in the immediate neighbourhood where these lights are used, which increase is directly traceable to the presence of the lights. Will this be the case with the introduction of the incandescent lamps? I believe not.

The popular error that there were millions in the lighting business has given the incandescent promoters command of almost unlimited capital: and with what results? Two examples will suffice to show. The Edison Electric Manufacturing Company claim to have at the present time 68 central station plants in operation, supplying current to upwards of 500,000 lamps, and representing an investment of about 12,000,000dols. (much the larger part of which has been thus invested during the last three years), with many large unfulfilled contracts on hand. In this country the first plant running on the alternating system was put in operation in 1885. At or near the beginning of 1887, the Westinghouse people began to place on the market this form of incandescent apparatus; and in less than eight months they had established fourteen such plants, supplying current to 15,000 lamps, representing a capital of about 350,000dols., with contracts amounting to nearly 120,000 dols. on hand.†

In view of these facts, is it not safe to predict that the same energy and push that characterised the locating of these plants will not rest until every town in Ohio, in the business portion of which 500 lamps could be placed, has been afforded the opportunity of using them? And if they are not furnished by the gas companies therein located, they most surely will be by someone else. Would a merchant be called enterprising who allowed a new article of merit, and in his line, and which he could have handled with profit, to be sold to a part of his best trade, to almost the exclusion of his own goods, simply because he refused to put it on the market, when he could have sold it at a less price, and at the same time made as large a percentage on the capital invested as did the other man? On the contrary, I think he would be called "slow."

The sceptical will no doubt ask, "What has all this to do with us?" Let us see. First, the introduction of an incandescent plant into the business district of a town means the loss of the gas consumption of at least one 5-feet burner for each incandescent lamp used. Secondly, the cost of a plant would depend largely on whether the direct current 3-wire or the alternating system were used; and this, as also the cost of running it, would depend on the circumstances under which the plant was to be operated—the distance of the lamps from the station, and the difference in the commercial efficiency of the generating apparatus coming in for due consideration. Supposing that the system requiring the least capital was embraced, we are told that the amount of investment—including land, buildings, steam plant, and complete generating and distributing apparatus erected and ready for use—would average 25dols. per lamp. Adding 10 per cent. to this, as a factor of safety, would make a 1,000-light plant cost 27,500dols.

The third question requires more in reply. We will take, for example, a plant located in a town, the business portion of which would use 1,000 16-candle lamps. With a 16-candle per five cubic feet gas, selling at 1·50dols. per 1,000 cubic feet, taking four hours as the average daily usage, the total consumption displaced per month would be $1{,}000 \times 5 \times 4 \times 30 = 600{,}000$ cubic feet, which at 1·50dols. per 1,000 = 900dols., or an average of 90c. per month per burner. Allowing for leakage a little less than 8 per cent., the net profit on the gas sold at that rate to pay 10 per cent. on the capital invested would be 55c. per 1,000 cubic feet, or 3·30dols. per month of 30 days. This would be the net reduction of the profits accruing to the gas business, resulting from the introduction of 1,000 incandescent lamps, if the current was supplied from 6 p.m. until 6 a.m.

Now, suppose the lamps were furnished at the cost of a 5ft. tip—viz., 90c. per month—the income from the 1,000 would be 900dols. per month. No meters being used, charging consumers with the cost of renewals of lamps, the company guaranteeing them to last 800 hours, would have a tendency to limit the hours of use to those specified in the contract; but they would still burn them more than they did the gas-jets. Allowing 33 per cent. for this increase, and dividing the lamps and hours of use thus:—

600 lamps	from 6 to 10 p.m.	4 hours	=	2,400 hours.
300 ,,	,, 6 ,, 12 ,,	6 ,,	=	1,800 ,,
100 ,,	,, 6 ,, 6 a.m.	12 ,,	=	1,200 ,,

we have a total of 5,400 hours per day, or an average of 5·4 hours per lamp per day. They would cost, with a consumption of 6lb. of coal per horse-power per hour, and an average efficiency of eight 16-c.p. lamps per horse-power, with coal at 2dols. per ton:—

125 h.p., 4 hours	= 125 × 4 × 6 =	1,500lb. (?)
50 ,, 2 ,,	= 50 × 2 × 6 =	600 ,,
12½ ,, 12 ,,	= 12½ × 12 × 11 =	1,650 ,,
Coal used for banking and starting fires		350 ,,
Total		4,100lb.

4,100lb. of fuel at 10c. per cwt.	$4.10
Water at 30lb. per h.p. per hour = 2,664 gals., at 50c. per 1,000 gals.	3.35
Proportion of superintendent's salary	2.00
Engineer and station man	3.00
Fireman	2.00
Day watchman	1.65
Lineman and helper	2.50
Repairs to engines, boilers, and dynamos, at 5 per cent. on investment	15.00
Oil	1.00
Interest, insurance, and depreciation at 16 per cent.	12.25
Taxes	0.60

The total daily expenses would be 32dols., or for an average month ($32 \times 30\frac{1}{2}$) 976dols. The income being 900dols., this would make a net loss of 76dols. per month. If placed at 90c. for those used until 10 o'clock, and 1dol. for those used until 12 o'clock, and at 2·70dols. for those used until 6 a.m., which would be the cost of a 5ft. gas-burner alight all night, the total income would be 1,060dols. per month; deducting 976dols. expenses, would leave a net profit of 84dols. per month, or 1,008dols. per annum—a little less than 3¾ per cent. on the capital invested. Such a plant would hardly be called a *bonanza*.

*A paper read at the annual meeting of the Ohio Gas-Light Association, March 21, 1888, and reprinted from the "Official Report," in the *American Gaslight Journal.*

† Later information credits them with having, up to the present time, put in operation 85 plants, supplying current to 175,000 lamps, and representing an investment of about 5,000,000dols.

In cases where, as Mr. Wood (in his paper on "Gas or Electricity") suggested, the waste heats could be used to such an extent as to save 50 per cent. of the fuel, and the balance could be made up of coke breeze, costing 1c. per bushel to handle, the expense of firing would be reduced at least one-half, making the whole cost of production per day—

For fuel, 2,050lb., at 1 cent per bushel	$0·52
Other expenses..	27·42
Total..	$27·94

In round numbers (28dols. × 30½) 854dols. for na average month. With an income of 1,060dols., and an expense of 854dols., we have a profit of (206dols. × 12) 2,472dols., or nearly 10 per cent. per annum on the capital, as estimated by the Westinghouse people. By the operation of an arc plant in connection with the incandescent, some of the items would be divided, making net earnings considerably larger. The cost as estimated here is, no doubt, larger than it would be placed at by the electrical engineers; but we had better err on the safe side.

The manufacture of a cheap fuel gas made use of in gas engines, together with the advantage of cheap and efficient storage batteries or accumulators, would lower considerably the amount of first investment, and at the same time cut down immensely the cost of production

It would seem, from the figures here given, that gas companies are much more favourably situated for furnishing both arc and incandescent lights, or electric currents, than anybody else; and that they should pursue the policy of fortifying themselves in their present positions by obtaining authority so to do, if necessary. Keep an eye on the public pulse; and if they will have it, give it them. By so doing they would make a powerful ally of what might, under some circumstances, be a formidable foe. Failure to occupy a field of action in advance of others sometimes results in disaster.

CORRESPONDENCE.

LONG DISTANCE TELEPHONY.

To the Editor of the Electrical Engineer.

Sir: I shall be glad if you can find space in your valuable journal for the following information under the above head:—

Through the courtesy of Mr. H. F. Jackson, of the National Telephone Company, I recently had the pleasure of speaking over the Sheffield to Manchester and Liverpool trunk line—distance, 144½ miles. Only 35 to 40 seconds elapsed before I was in direct communication with Manchester, and, after finishing conversation, I was switched on to Liverpool in about the same space of time. To both places the conversation was carried on just as easily as if we were only a mile distant. I was also in communication with Leeds and Bradford in similar time. I marked the easy and rapid manner in which the switching was carried out to each town. Having been district manager for the National Telephone Company's Nottingham division for a period of seven years, I can speak from experience upon this subject. I failed to find the slightest interruption from induction influence. I understand that the longest trunk line in Great Britain is from Sheffield to Fleetwood. As soon as Sheffield is in communication with Nottingham—and this line is now being built—the distance from Nottingham to Liverpool will exceed 200 miles as the line will run. Birmingham is also being connected with Nottingham, and with Sheffield and North Yorkshire *viâ* Derby and Chesterfield. Such communication to these important centres must be a great boon to the commercial community generally. I may also mention that the service from Glasgow down the west coast and to the Scottish capital is most excellent.

A few weeks since, I also had the pleasure of speaking over a long trunk line of the Western Counties Telephone Company, by the kind permission of Mr. H. F. Lewis, the general manager, Bristol, between that ancient city and Llanelly (South Wales)—distance 128½ miles, including a cable across the Severn Bridge. Particulars of towns and distances are given below. I was in communication with Swansea within one minute, when, after conversation, I was asked to be switched on to Llanelly. This occupied about 45 seconds. The communication was perfect in every respect. The following are the trunk lines, &c., of the Western Counties Company:—

From	To	Wire Distance Miles.	Remarks.
Bristol	Bath	14	...
do.	Gloster	39	... Via Sharpness and Severn Bridge.
Do.	Newport	52½	... Do.
Do.	Cardiff	66½	... Do.
Do.	Pontypridd	78½	... Do.
Do.	Briton Ferry ...	111½	... Do.
Do.	Swansea	116½	... Do.
Do.	Llanelly	128½	... Do.
Swansea.........	Landore	2	... —
Do.	Morriston	3	... —
Do.	Neath	6	... —
Pontypridd ...	Aberdare	12	... —
Do.	Merthyr	16	... —
Newport	Pontypool.........	11	... Now in course of erection.
Do.	Aberyschan	14	... Do.
Do.	Tredegar	23	... Do.
Bournemouth	Poole...............	6	... —
Torquay	Newton Abbott	6	... —
Do.	Paignton	2	... —
Do.	Totnes	10	... Now in course of erection.

Length of cable at Severn Bridge is armour-plated in canal	170 yards.
Lead covered on bridge	1,150 ,,
	1,320 ,,

Mr. Lewis states that the longest distance spoken by them is from Bath to Llanelly, a wire mileage of 142½ miles. The speaking was in every way perfect and commercially good.

I must not forget, also, that I had the same pleasure extended to me by Mr. C. B. Clay, the General Manager of the Northern District Telephone Company, Sunderland, whose trunk-line system I also give below. I found the switching similar in space of time as over other systems. I failed to observe any induction over any section of the trunk lines, which are erected in the twisted metallic circuit system. The wires in Yorkshire and Lancashire however, are all single, and at the time of my trial were perfectly quiet, though I am informed that there is generally some induction disturbance, though so slight as to be of no practical consequence.

While speaking between Sunderland, Newcastle, Middlesboro', and Darlington, intermediate stations, a heavy thunderstorm was reported from these stations, but no interruption was observable, and the conversation, switching, &c., was carried out without the slightest difficulty.

The following are the trunk lines of the Northern District Co.:—

From.	To.	Miles.	Remarks.
Sunderland.....	Durham	18	Twist system.
Do.	Middlesboro'......	40¼	Do.
Do.	Hartlepool	25¼	Do.
Do.	Stockton	36¼	Do.
Do.	Darlington	48¼	Do.
Do.	Newcastle	14	Do.
Do.	N. Shields.........	20¼	Do.
Do.	Blyth...............	33	Do.
Do.	Middlesboro'......	68	*Via* Newcastle.

The National Telephone Company, for their local exchanges, for the past five years or more have used bronze wire, manufactured by the Phosphor-Bronze Company, Sumner-street, Southwark, London; and similar wire is now, and for some time past has been, exclusively used by the Western Counties, South of England, and Northern District Companies for local service, and, I understand, has given universal satisfaction, it having great tensile strength, resistance to oxidation and elongation. The tensile strength of bronze wire not being mechanical after a heavy fall of snow or other strain on the wire, it recovers its normal position, which copper or other wire fails to do; and consequently, where copper wire is used, the cost of maintenance is much heavier, apart from the inconvenience caused to subscribers by the lines being frequently interrupted. As the so-called hard drawn copper in long spans has simply a mechanical strength, being erected in long spans such as it is impossible

TABLE A.—EXPERIMENTS ON SILICIOUS-BRONZE WIRE.

Diameter.		Weight per mile in pounds.	Elongation per cent.	Breaking weight in tons per square inch.	Twists in 6in.	Resistance in ohms at 60° F.		Conductivity. Copper=100.	
Inch.	Mm.					Per mile.	Per foot-grain.		
·080	2·056	102 65	1·5 : 1·0 2·0 : 2·0	27·61	13 : 16 23 : 35	8·6359	0·22258	94·616	
·059	1·529	58·651	nil nil	29·368	21 : 25 27 : 53	15·437	0·22734	92·637	Phos-phor bronze.
·044	1·133	32·31	nil nil	47·406	24 : 25 24 : 26	90·333	0·73285	22·826	
·036	0·936	22·698	nil nil	50·07	23 : 19 11 : 22	157·39	1·4375	14·65	
·081	2·072	102·17	1·5 : 1·0 1·5 : 1·0	29·022 27·47	47 : 19 16 : 20	8·5009	0·21807	96·571	

to prevent in towns, it gradually loses its strength, whereas bronze wire, after being erected years, remains the same.

Mr. Preece's paper on "Electrical Conductors," read before the Institution of Civil Engineers on Dec. 4, 1883, touches upon this point, an extract of which is given below.

"*Bronze Wire.*—Phosphor-bronze, whose hard mechanical qualities and great resisting powers are well known, was introduced for telegraph wire about five years ago. Several lengths were erected by the Post Office. Two long spans crossed the channel that separates the Mumbles Lighthouse from the headland near Swansea. The object in view was to obtain great tensile strength with a power to resist oxidation, especially active where the wire is exposed to sea spray. This was done in 1879, and now, in November, 1883, *not the slightest change is noticeable in the wire.* But phosphor-bronze, though extensively used, has high electrical resistance; its conductivity is only 20 per cent. of that of copper. Moreover, the phosphor-bronze supplied was irregular in dimensions and brittle in character. It would not bear bends or kinks. A new alloy, silicious-bronze, has recently been introduced to remedy these disadvantages.

"Phosphor and siliciousbronze derive their names, not so much because the materials prefixed are mixed with the copper, but because they are used in the preparation of the alloy. Pure bronze is a mixture of copper and tin, and in the refining and mixing process phosphorus and silicium have the property of removing impurities, particularly the oxides, though, doubtless, some of the flux remains. Phosphorus has a most injurious influence on the electrical resistance of the alloy. Silicium is far superior; hence the silicious-bronze is preferable for telegraphic purposes. Its efficiency is very great; in fact, phosphor-bronze has disappeared for telegraph wire, and has been replaced by silicious-bronze.

"The electric resistance of silicious-bronze can be made nearly equal to that of copper, but its mechanical strength diminishes as its conductivity increases. Wire whose resistance equals 96 per cent. of pure copper, gives a tensile strength of 28 tons on the square inch, but when its conductivity is 34 per cent. of pure copper its strength is fifty tons on the square inch. Its lightness, combined with its mechanical strength, its high conductivity, and its indestructability, rendered it eminently adapted for telegraphs.

"Table A gives the results of some tests made by the Post Office upon specimens submitted for trial.

"Long telegraph lines, for which iron wire weighing 400lb. per mile is now used, can be made of bronze wire weighing 100lb. per mile, which would give higher electrical efficiency; and over-house lines, for which steel wire is often used, can be replaced efficiently by bronze wire weighing only 30lb. per mile, which would be almost invisible.

"If overhead wires were erected of such a material, upon sightly supports, and with some method, there would be an end to the meaningless crusade now made in some quarters against aerial lines. These, if constructed judiciously, and under proper control, are far more efficient than underground lines. Corporations and local authorities should control the erection, rather than force administrations to needless expense and to reduced efficiency by putting them underground. Not only do light wires hold less snow and less wind, but they produce less electrical disturbance, they can be rendered noiseless, and they allow existing supports to carry a much greater number of wires. Other bronzes have been tried, but without any evident advantage, either in quality or in price."

Yours, &c., JAMES O. FRY.

4, Avenue-villas, Cricklewood, N.W.

PHYSICAL SOCIETY, April 28th.

PROF. REINOLD, F.R.S. (President), in the chair.

The following communications were read:—

"On Electromotive Force by Contact," by Mr. C. V. BURTON, B.Sc. The object of the paper is to discuss the seats of the electromotive forces developed by the contact of conductors. By considering the distribution of electricity on the surfaces of the conductors, and from the fact that the potentials throughout their masses are constant, except about a thin layer near the junction, the author deduces that *the molecular action which gives rise to a contact E.M.F. between two conductors is confined to the immediate neighbourhood of the junction.* If E be the contact E.M.F., and M the quantity of electricity which passes across the junction when two metals originally at the same potential are placed in contact, it is shown that the work done is E M., half of which is spent in producing heat, and half in raising the potential energy of the system. Since the conductors are supposed to be kept at a constant temperature, and the action which gives rise to the E.M.F. is confined to the immediate neighbourhood of the junction, the molecular energy must be absorbed *at the junction.* By supposing the surface of contact very small and the capacity of the system large, it is shown that *heat* and *chemical action* are the only kinds of energy which fulfil the required conditions of supplying an indefinite amount of energy. Hence, for substances chemically inactive, *the true contact E.M.F. is equal to their co-efficient of the Peltier effect expressed in absolute measure;* and for substances chemically active, but devoid of Peltier effect, *the E.M.F. is equal to the energy of combination of one electro-chemical equivalent.* Since metal-metal contacts can only be the seats of Peltier E.M.F's., it is inferred that the *apparent contact E.M.F.* (measured inductively) must be due chiefly to air-metal contacts. A list of analogous properties of Peltier and chemical E.M.F's. is given in parallel columns. The results of some experiments on the contact E.M.F. of glass and ebonite with mercury are tabulated, but they are very irregular; and the author concludes that there is no true and definite contact E.M.F. between conductors and non-conductors.

Profs. Ayrton, Schuster, Thompson, and Perry discussed the points raised, and it was considered that direct experiment on contact E.M.F. in a very perfect vacuum could alone decide the questions.

"On a Theory concerning the Sudden Loss of Magnetic Properties of Iron and Nickel," by Mr. H. TOMLINSON, B.A. Experiments by himself and other observers have shown that the temperatures at which iron and nickel lose their magnetic properties depend on the specimens used and the magnetising forces employed; but the temperature at which they *begin to lose* these properties are definite—for nickel about 300deg. C., and iron about 680deg. C. The author's own experiments on "Recalescence of Iron" show two critical temperatures, and Pinchon has shown by calorimetric measurements that between 660 and 720deg. C. and between 1,000 and 1,050deg. C. heat becomes latent. All these facts seem to indicate a molecular rearrangement about these temperatures. In his proposed theory, he assumes that the molecules of iron (say) contain magnetic atoms capable of motions of translation and of rotation. These tend to form closed magnet'c circuits, but at ordinary temperatures are unable to do so on account of the close proximity of their centres. On raising the temperature, their centres are further separated till, at about 680deg. C, their polar extremities rush together, forming complete circuits, and exhibiting no external magnetic properties. On cooling down, the centres approach until the gravitation attraction overcomes the magnetic attraction of their poles, when the magnetic properties reappear. **Prof. Ayrton** asked whether the author had made experiments on the reappearance of magnetic properties when raised to a white heat, and **Prof. Thompson** inquired whether cobalt had been tested. Both questions were answered negatively.

"Note on the Graphic Treatment of the Lamont-Frolich Formula for Induced Magnetism," by Prof. S. P. THOMPSON, D.Sc. The formula referred to is $\mathrm{N}=\mathcal{N}\frac{\mathrm{S}i}{\mathrm{S}i+b}$, where $\mathcal{N}$=total induction when saturated, N=induction due to Si ampere, turns, and b=value of Si, which makes $\mathrm{N}=\frac{1}{2}\mathcal{N}$. Simple geometrical constructions are given for plotting the curve when $\mathcal{N}$ and b are known, and for finding $\mathcal{N}$ and b when two pairs of values of N and Si have been determined. The use of the formula is shown to be justified in practice, for, as pointed out to the author by Prof. Perry, the curves connecting permeability, μ, and induction, B, are straight lines from B=7,000 to B=16,000, between which dynamos are usually worked. A method of predetermining $\mathcal{N}$ and b is given for magnetic circuits of known form and materials, thus removing the objection often urged against the above formula—viz., that it involves two constants which had to be determined after the magnet was made.—Two other "Notes" by the same author were postponed till next meeting

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S

GAS COMPANIES AS CONTRACTORS.

The abstract of a paper read in America before one of the gas associations, which abstract we print elsewhere, directs the attention of all those engaged in the gas industry to the question whether it will not be to their advantage to take the bull by the horns, and harness the electric lighting industry to the car they already drive to such good purpose, at least so far as dividends are concerned. Epicures are frequently heard to expatiate learnedly upon acquired tastes. The palate does not take favourably to some kinds of food when presented to it for the first time; but with a little tempting and a little education, that which originally produced a feeling of nausea becomes savoury and agreeable. The electric light is as yet in the nausea-producing stage, so far as the gas people are concerned; but the bait may prove too tempting, and ere long may be swallowed. There is a grand opportunity now, though year by year this opportunity will slip away, and the gas companies, instead of guiding and controlling, will find their power for good or for evil entirely vanished.

> "Knowledge comes, but wisdom lingers, and he bears a laden breast
> Full of sad experience, moving towards the stillness of his rest."

The advice we tender now has been given before, but such was the contempt for the new illuminant, that chairman after chairman presiding at gas companies' meetings treated the possibility of electricity competing with gas as a question unworthy of discussion; the competitor they feared was not electricity; it was oil. Verily, knowledge will come, though wisdom lingers; and the time will come when chairmen will be compelled to acknowledge that the gas industry has something to fear from electricity. However, it is not our intention to sermonise to the directors of gas companies. They are not desirous of being convinced that a little more knowledge is by no means a dangerous thing, but partake something of the character of the sluggard, who, as we all know, was perfectly indifferent to the state of his garden so long as he was not bothered to wake up. But

> "Not in vain the distance beacons. Forward, forward let us range,
> Let the great world spin for ever down the ringing grooves of change."

The change is coming, it is as certain as that the world exists. The luxurious—those who can well afford luxuries—are quietly but quickly replacing the old methods of illumination by the new. They do not affect oil; they invariably replace what went before by means of the far better, purer, and intenser light evolved by electricity. This is as it should be. The light is a luxury; but, like other luxuries, as the demand increases it becomes cheaper, and so gets within the reach of a greater and a greater number, till ultimately what originally was a luxury, and nothing but a luxury, becomes a necessity, and is to be found in every house. Knowledge is increasing, and with the increase it becomes known that the method of comparing the cost of the electric light with that of gas is altogether misleading. If a householder

pays ten pounds a year for his gas bill, and a second ten pounds a year to get cleared away the dirt caused by the use of gas, the cost of the light is just double its nominal cost, and, further, if he can get the electric light for double the nominal cost of gas, he is thereby a gainer and not a loser.

The moral we have to point out is that directors of gas companies are missing the grandest opportunity of the century in not throwing themselves heartily into the work of developing the electric light industry. They are in a position which, rightly used, would give them almost as complete a monopoly of the one system as they have of the other. Their advantages are great. They have generally spare ground. They have a good deal of spare waste heat. They have a cheap fuel in the shape of coke. They have the opportunity of breaking up streets in many instances without danger of troubles arising with the local authorities. If the Acts which authorise their existence have not sufficient latitude, a very little expenditure is necessary to enlarge their powers. No opposition would be likely to be encountered in getting such powers. The shareholders are local men, many of whom, though hankering after the electric light, cannot bring their hearts to favour its introduction, because they think it would tend to lower dividends or the quoted price of their shares. If, however, the gas company were in a position to offer the alternative light, no doubt a sufficient number of subscribers would be found around every gasworks to make even the first little installation a paying concern. If the directors have not sufficient perspicacity to see the tendency of things electric, it is almost time that shareholders commenced to bestir themselves in order to get a management holding wider views, and anxious to be well abreast of the times. The gas interests took fright three or four years ago, when there was really no wolf in existence—only a cub; but that cub has been growing and growing, till it is rapidly assuming all the external characteristics of a full-grown wolf. Familiarity with the growing cub has engendered a contempt the existence of which will probably lead to a rude awakening at no very distant date. If it were not that the innocent shareholders are likely to suffer from the crass stupidity of those who guide the vessels, we should say: let these directors stew in their overweening ignorance; but it is so evident that they do not realise the position of affairs that a warning is necessary. We contend that electric lighting will eventually supersede gas lighting, that the new lighting could be carried out better by the existing lighting companies, with less derangements of interests, with less shifting of capital, and with more rapid extension than by the aid of competing companies. Of course we assume that if the existing companies took up the work it would be with a view of carrying it out satisfactorily, and not in a manner to try and make consumers dissatisfied with it. Any attempt in the latter direction would undoubtedly bring about the catastrophe earnest and honest people are anxious to avoid. This article is sufficiently lengthy without adding more. The suggestion it contains is for consideration. A due appreciation of the signs of the times will prove that it is not ill-timed. Town after town is enquiring—a few will adopt the electric light. The enquiries will continue if the light is fairly successful, and the percentage adopting the light will become greater and greater. With regard to the success of the light, the gas journals are filled with a simpering inanity of ifs and buts, of flouts and jeers, all to make believe that the word failure is writ large upon every bit of work of the electric engineer. A greater mistake could not be made. Failures there are, and always will be. Good work is not always paid for, and sometimes when paid for is not given; but many engineers will guarantee success under all ordinary circumstances, and will, with greater confidence, daily point to a dozen successes to one failure. There is not hope for the scornful in this direction.

PRIESTMAN'S PETROLEUM ENGINE.

In our last issue we gave the report of Prof. Jamieson on the Griffin Gas Engine. Such engines, of course, suppose that the gas required for their working could be obtained, either from the gasworks in the vicinity, or—perhaps, preferably so far as economy is concerned—by using the Dowson process for making the gas as required. This week we illustrate an engine which possesses many advantages, one of which, and possibly not the least, is that it only consumes a material which is easily obtained everywhere, and does not depend upon the erection either of a small special plant, or the vicinity of the works. We refer to Priestman's latest form of the Etève engine We have before us a number of reports as to the performances of this engine, and we have ourselves examined one at the offices of the firm in Queen Victoria-street. Sir Wm. Thomson in his report, among other things, says :—

"I made careful tests on a 6-h.p. engine. After seeing it started and stopped several times, and kept running on the brake for an hour at 7½-h.p., and for two hours at 6-h.p., without measuring the oil, I gave it exactly an hour's run with the brake loaded slightly more than for 6-h.p., and with arrangements to measure the oil accurately. The result was that the engine ran with very admirable regularity at from 158 to 160 revolutions, doing 6·43-h.p on the brake. The quantity of oil used was very exactly 11 pints, being at the rate of 1·71 pints per hour per brake horse-power, or 1·69 pounds per hour per brake horse-power, which seems to me remarkably good economy, considering the great difficulties which had to be overcome in using the combustion of oil directly as a motor. It must be noted that these results refer to the horse-power of work actually done externally by the engine, and not merely to 'indicated horse-power,' which in the steam-engine, and still more in the gas-engine, falls short of true horse-power by a large difference. Messrs. Priestman's engine, unlike one upon another system to which my attention has been called, does not use only the lighter portion of the oil, leaving a large residuum, which cannot be utilised, but has the great advantage of consuming the whole of the oil put into the cistern, which I verified by careful examination of the working of the engines which I tested. By a new and effective mode of regulating the supply of vapour to the cylinder, combustion so perfect is obtained that deposit of carbon in the cylinder and passages is most satisfactorily

obviated, as I have myself verified by careful examination. As the engine is governed by reducing the charge admitted into the cylinder, instead of cutting off the supply, the explosion takes place with great regularity, thus securing steady running with or without load, and with varied loads, which, judging from my own experience of the irregular running of gas-engines, running at anything less than full load, is a very important advantage."

The following details are taken from a report of Sir Samuel Canning and Messrs. Alabaster and Co. as to an engine at work at the Electrical Power Storage Company:—

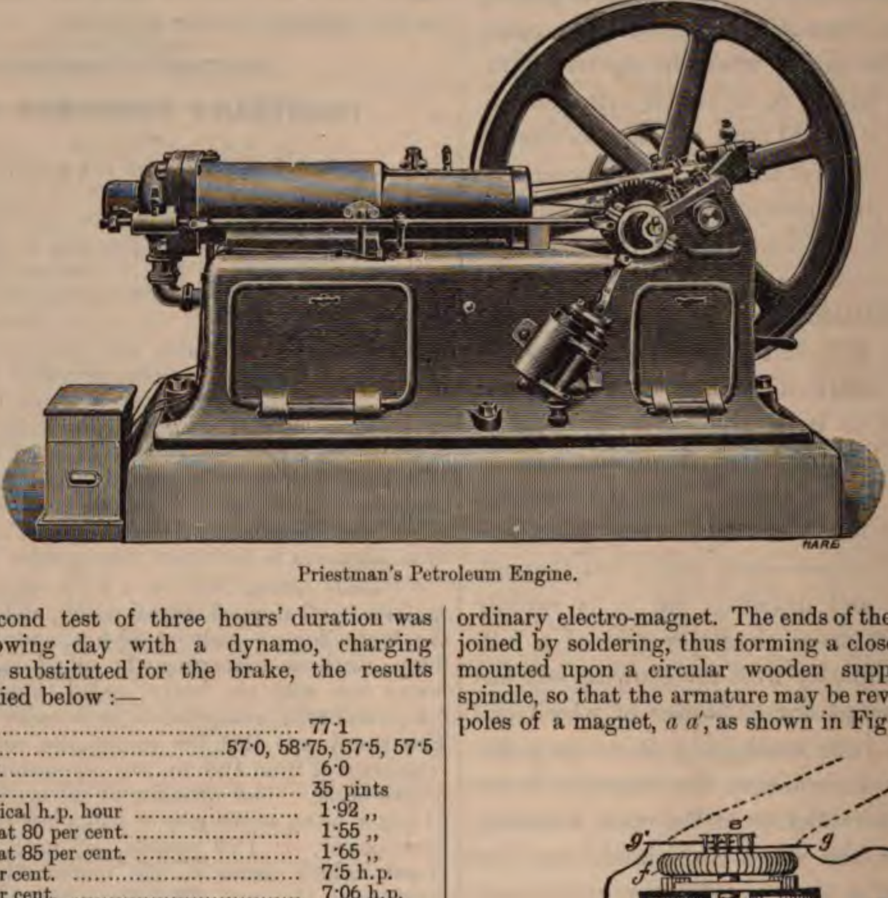
"The cylinder is 10in. in diameter, with 15in. stroke; the fly-wheel being 5ft. 6in. in diameter. The engine runs regularly, whether with full load or light, at about 160 revolutions per minute. Our tests were made with a brake, also with a dynamo used for charging secondary batteries, giving, it was said, 85 per cent. of the engine-power in the external circuit. This efficiency does not appear to be exaggerated, as, according to the tabulated results, the oil consumed per brake h.p., and with the dynamo at 85 per cent., agree closely. However, to be within safe limits, we have also given the results at only 80 per cent. The following table gives the result of one hour's run with brake:—

Revolutions per minute	160
Brake horse-power	6·438
Oil consumed, in pints	10·8
Oil consumed, in pints, per b.h.p.	1·68

At the end of the trial, the cylinder and the points and insulators in the sparking or firing plug were found to be quite clean. A second test of three hours' duration was made on the following day with a dynamo, charging secondary batteries, substituted for the brake, the results of which are embodied below:—

E.M.F. volts	77·1
Amperes average	57·0, 58·75, 57·5, 57·5
Average Electrical H.P.	6·0
Total oil consumption	35 pints
Consumption per electrical h.p. hour	1·92 ,,
Oil per h.p., delivered at 80 per cent.	1·55 ,,
Oil per h.p., delivered at 85 per cent.	1·65 ,,
Delivered h.p. at 80 per cent.	7·5 h.p.
Delivered h.p. at 85 per cent.	7·06 h.p.
Cost per h.p. hour at 80 per cent.	1·25 pence
Cost per h.p. hour at 85 per cent.	1·34 pence
Revolutions of engine	160 per min.

The current was measured by means of an Ayrton and Perry instrument, checked by a standard Siemen's electrodynamometer, and the readings of an accurately and recently calibrated voltmeter were corrected for temperature. It appears, then, that the cost per actual horse-power is approximately 1¼d. per hour, with oil at 6½d. per gallon; but as the probabilities are greatly in favour of considerable reduction in its price, it would seem that in the near future a very great economy will accrue from the employment of this engine. . . . . . We may add that the maintenance of the battery (zincs and solution) for supplying electrical energy to the induction coil would cost about 60s. per annum, or about 2½d. per day of nine hours. For engines of the type tested by us, it is evident that the employment of petroleum, even at the price here quoted, will compare favourably with gas in this and other countries at any price above 3s. 6d. per thousand cubic feet."



Priestman's Petroleum Engine.

EXPERIMENTS ILLUSTRATING THE PRINCIPLE OF THE DYNAMO.

BY GEO. M. HOPKINS.

II.

After noticing the effect of plunging a magnet into a coil of wire, it is not very difficult, in the light of present electrical knowledge, to understand how the process of induction is carried on in a continuous way in the armature of a dynamo.

The simplest form of armature for illustrating this point is undoubtedly that known as the Gramme ring armature. In the action of this armature the prime factor is magnetic induction. It is perhaps unnecessary to go into the details of the construction of the Gramme ring as commonly used in dynamos. A very crude ring answers the present purpose. Its core is formed of a compact circular coil of soft iron wire, which, in cross section, may be circular or of any other form. The core is wrapped with tape, and varnished to insure insulation.

Around this iron ring or core is wound an insulated copper wire, arranged in a spiral coil, *f*, like the winding of an ordinary electro-magnet. The ends of the copper winding are joined by soldering, thus forming a closed coil. The ring is mounted upon a circular wooden support attached to a spindle, so that the armature may be revolved in front of the poles of a magnet, *a a′*, as shown in Fig 9. In the wooden support, in a circle concentric with and near the spindle, are inserted six or eight wire nails, *e′*, arranged at equidistant points. The copper winding of the ring is spaced off into as many sections as there are nails in the circular row, and at the end of each section the insulation of the

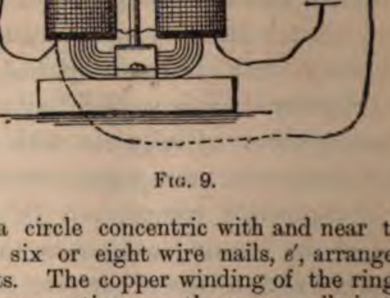


Fig. 9.

copper wire is removed a short distance, and a wire, *i*, is attached by soldering. These attached wires are each connected with one of the wire nails. Now, all that remains to complete the Gramme dynamo or motor is the application of two conductors, *g g'*, to the circular row of wire nails, as shown in Figs. 10 and 11.

Fig. 10.

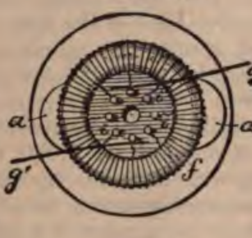


Fig. 11.

This dynamo has all the essential features of the regular machine—the field-magnet, the iron armature core, the conductor wound upon the core, the commutator cylinder formed of the wire nails, and the brushes consisting of wires held on opposite sides of the commutator cylinder.

This dynamo is constructed for illustration only, and not for practical use. It will generate a current, and may be driven as a motor by a current, but of course not with the same advantage as a more complete machine.

In investigating the phenomena of the armature, it is well to begin with the simplest case of magnetic induction. When a bar of soft iron is held before the poles of a magnet, as shown in Fig. 12, it becomes itself a magnet.

Fig. 12.

Fig. 13.

The magnetism developed in the bar by the action of the magnet is opposite that of the magnet. That is, the magnetism developed in the end of the bar opposite the N pole of the magnet is S, and, similarly, the magnetism developed in the end of the bar opposite the S pole is N. The centre of the iron bar is neutral.

By substituting an iron ring for the straight bar, as shown in Fig. 13, the effect will be the same. The portions of the ring opposite the poles of the magnet acquire polarity by induction, as in the first instance, and the magnetism extends in the ring from the vicinity of the poles toward the neutral line, X X, which forms a right angle with a line joining the poles of the magnet. In the figure of the ring the location of the magnetism in the ring is indicated by the shading.

Fig. 14.

By turning the ring upon its axis, the mass of the ring moves, but the polarity of the ring maintains a fixed position relative to the poles of the magnet.

When the ring carries a coil, as shown in Fig. 14, the magnetic poles of the ring remaining stationary, while the material of the ring and coil are revolved. There is a continual passing of the sections of the coil through the magnetic field surrounding the polarised portions of the armature core and the poles of the magnet, which is the same in effect as the passing of a magnetic bar through the coil of the armature.

Besides the inductive effect produced by the magnetisation of the armature core, the passing of the conductor through the magnetic field of the inducing magnet augments the current.

Each half of the armature between the neutral points is practically a single coil of wire, terminating at two of the commutator bars—which in the present case are the two nails—at diametrically opposite sides of the commutator cylinder; all of the remaining commutator bars and their connections being idle.

In Fig. 9, two circuits are shown in connection with the machine—one in full lines, the other partly in dotted lines—both connected with the battery, *c*. When the circuit, represented in full lines, only is employed, the machine runs as a motor. When the wires, shown by full lines, are disconnected from the brushes, *g g'*, the rotation of the armature in the field of the magnet, *a a'*, produces a current in the manner already indicated, and this current is taken from the armature by the way of the wires, *i*, the nails, *e'*, and the brushes, *g g'*.

This machine, when used as a generator, is strictly a magneto-electric machine, although an electro-magnet is employed as a field-magnet. A permanent magnet might be substituted for the electro-magnet.

For the sake of securing the greatest possible simplicity, certain modifications of the action of the armature have been omitted.—*Scientific American.*

ELECTRICAL TRAMWAYS: THE BESSBROOK AND NEWRY TRAMWAY.*

BY EDWARD HOPKINSON, M.A., D.SC., ASSOC. M. INST. C.E.

(Continued from page 402.)

Comparing the proportion of the total energy of the water, which can be applied to traction in the electrical locomotive, with the proportion of the total energy of coal, which can be usefully applied in a steam locomotive, the former has been seen to be over 40 per cent. Mr. G. C. Cunningham, M.Inst.C.E., estimates the latter from experiments tried on the Canada Southern Railway at 3·5 per cent.*

Referring again to Table IV., if the work done against gravity be subtracted from the total work done by the motor, the remainder represents the work done against all the frictional resistances. From this and from the distance traversed the mean tractive force can be at once deduced. The results for the three journeys are, respectively, 28·9, 27·4, and 37·1lb. per ton of gross load hauled. The two former agree well. The increase in the third is due to two causes: first, the mean speed is nearly double that in the first journey, the effect of which on the mean tractive force would be increased by the frequent and sharp curves of the line; secondly, the locomotive car having no trucks attached to it on the third journey, the friction of the driving gear, connecting rods, &c., would bear a much larger proportion to the whole. The values given above for the tractive force include the friction of the chain and driving-gear, as also that of the motor dynamo in its bearings, and the couple required to turn the armature with the fields excited, but no current passing through it. It corresponds in a steam locomotive to the product of the mean pressure on the piston and the ratio of the throw of the crank to the radius of the driving-wheel.

The foregoing results also afford some examples illustrative of the general theory of a series-wound motor. In such a motor let L be the couple on the armature shaft; R the resistance of the series coils and armature; r the additional resistance inserted; C the current; P the potential of the conductor; E the electromotive force of the motor; and ω the angular velocity of the armature. Then

$$L\omega = EC$$

$$\text{And } E = P - \overline{R + r}\,C.$$

* Minutes of Proceedings, Inst. C.E., Vol. lxxxiii., p. 325.

$L\omega$ here includes the power lost in the armature of the dynamo through the reversal of its magnetisation, the power lost through the short-circuiting of successive coils at the commutator and local currents in the core, also friction of the bearings, in addition to the useful work done by the motor, as measured by a brake. The first of these losses, which is, or ought to be, the most important, is proportional to the velocity ω, and the latter, with sufficient accuracy for the present purpose, may be assumed to be so. $(L + l)$ may therefore be written for L, where L represents the couple doing useful work external to the dynamo. Let $E = \frac{\omega}{\Omega} f(C)$ be the characteristic curve of the dynamo, then—

$$L + l = \frac{C f(C)}{\Omega}.$$

C is therefore independent of the velocity, and depends upon the couples only. It must be remembered that C being measured in amperes, L and l are measured in the corresponding C.G.S. unit of work denominated by the late Sir William Siemens a "Joule." (One Joule $= 10^7$ ergs $= 0.74$ foot-lb.) Since within very wide limits $f(C)$ increases as C increases, $L + l$ increases as C increases. In this lies the chief advantage of a series-wound dynamo for locomotive purposes. The maximum couple which a steam locomotive can exert is limited by the steam-pressure and the area and stroke of the piston. In a water-wheel the couple cannot exceed the product of the radius of the wheel and the maximum weight of water its buckets can contain. So in a turbine. In a series-wound dynamo there is no limit to the couple it can momentarily exert, except the mechanical strength of the armature, provided the potential of the conductor does not fall below $\overline{R + r}\,C$. It may be said that the current is limited by the couple turning the generating dynamo. This no doubt is true, but in many cases the generating dynamo is sufficient for working several motors, and the motor which at the instant requires to exert the greatest pull can draw the full current of the generator; and in every case there is the momentum of the generating dynamo and of the engine or other prime motor driving it, which must be exhausted before the amount of current is limited. In the present instance, the motors on the cars are designed for working continuously with a current of 72 amperes, with which current the couple the dynamo exerts is 183 Joules, or 135 foot-lb., which is increased to 1,120 foot-lb. on the axle, equivalent to a tractive force of 960lb. The observed current required to start a train of 29 tons on an incline of 1 in 50 was 170 amperes (Plate 1, Fig. 1), corresponding to a tractive force of 2,544lb., equal to 88lb. per ton, or about three times the normal tractive force exerted by the motor. For a line such as the one under discussson a simple shunt-wound motor would be useless, since at the moment of starting on a steep incline the potential of the conductor at the motor may be reduced to one-half its normal amount through the resistance in circuit, and consequently the magnetising force reduced in like proportion, when the fields would almost entirely lose their magnetism. A compound-wound machine might be used, and would have the advantage that the speed would not exceed a certain limit however small the load might be, but in the present instance such a provision was unnecessary. A further advantage in the use of a series-wound machine is the facility with which a motor of the Edison-Hopkinson type when wound in this manner can be reversed. In general, to reverse the direction of rotation of a motor, the lead of the brushes must be reversed at the same time as the current through the armature, or there will be destructive sparking at the commutator. But if the lead can be reduced to such an extent that the brushes may be fixed at the neutral point without causing injurious sparking, it is only necessary to reverse the current. It is known that the angle of lead depends upon the disturbance of the magnetic field in the gap between the pole-pieces, due to the current round the armature, but no successful attempt has yet been made to express the variation of the angle of lead in terms of the geometrical constants of the machine and the magnetising forces. The disturbance of the field can, however, be minimised by maintaining the magnetising forces in the field magnets very large compared with those in the armature, as is the case in a series-wound machine. In the present instance it has been found unnecessary to make any provision for the change of lead, and the reversal of rotation is effected by reversing the current only.

Referring to curves, Plate 1, Fig. 1, it is seen that on an incline of 1 in 621 the locomotive car, when drawing a gross load of 28·6 tons, absorbed a current of sixty amperes, and that the electromotive force of the motor was 222 volts. From these measured results the couple exerted by the motor and the speed can be readily determined by aid of the characteristic curve. With a current of 60 amperes through the magnet coils, the electromotive force of the motor is 260 volts at a speed of 1,000 revolutions per minute, and, therefore, with 222 volts the speed will be 854 revolutions per minute, corresponding to a speed of travel of 8·57 miles per hour as against 8·4 miles measured. Again, the couple exerted by the motor will be

$$\frac{222 \times 60 \times 60}{854 \times 2\pi} \text{Joules} = 149 \text{ Joules} = 110 \text{ foot-lb.}$$

This is equivalent to 913 foot-lb. on the axle of the car, or a tractive force of 785lb., *i.e.*, 27·4lb. per ton. From this must be deducted 3·4lb. per ton for gravity, leaving 24lb. per ton, as against 28·9lb., the tractive force calculated from the mean of the work done over the complete journey. In the latter the force required to overcome the resistance of the curves, which are both numerous and sharp, is included, whereas the former figure applies to a straight portion of the line. This is probably sufficient to account for the difference between the figures. The example shows how precisely the results obtainable from an electromotor when used for locomotion can be calculated.

USE OF STORAGE BATTERIES.

It is interesting to consider how far the system of storage batteries would be applicable to a line where heavy traffic has to be accommodated. In the first journey, with a load of 28·6 tons, the total work done by the motor was 12·6 h.p. hours, and the loss in the motor was 2·07 h.p. hours; hence the total electrical energy absorbed by the motor was 14·67 h.p. hours in thirty-six minutes, or at the rate of 24·4 h.p. According to results published by Mr. Reckenzaun in a communication to the American National Electric Light Association, a cell suitable for tramcar work weighing 41lb. has a useful capacity of 137 to 156 ampere-hours, according as the rate of discharge is varied from 46 to 22 amperes; the electromotive force falling during discharge from 2·1 volts to 1·87 volt. Hence one ton of storage cells can do work usefully at the average rate of 3,700 watts, or 4·9 h.p. From these data the weight of battery required to do the work actually accomplished at Bessbrook can be readily deduced. Remembering that the battery itself has to be carried, and making no allowance for increased weight in the framework of the car, the weight of battery required is six tons. But this additional weight would necessitate a considerably larger locomotive power with a stronger frame and more powerful motor, which would again increase the weight of the train and the weight of the cells required. If the former be taken at 4·4 tons, the latter would be about one ton; hence the gross weight of the train would be increased to 40 tons, including the battery, weighing 7 tons. Assuming the efficiency of the battery to be 70 per cent., which is probably a favourable assumption when the rate of discharge is variable, the electrical energy required to charge the battery for one journey would be 29·3 h.p. hours as against 16·4 h.p. hours required for the same work on the continuous conductor principle. Thus, from the point of view of economy of power, the comparison is greatly in favour of the continuous conductor. There are the further considerations of first cost and depreciation of plant. To provide for the continuous working of the line, two sets of accumulators would be required, which, taken at the present price of £60 per ton, would cost £840, to which must be added the cost of the larger locomotive cars and more powerful motors. This would increase the cost to at least £1,200. Now, the cost of the conductor, which is the only part replaced by the battery, was £600 (see appendix). Again, the depreciation

of the cells cannot be estimated at less than 40 per cent. per annum, whereas the conductor practically suffers no depreciation.

COMPARISON WITH WIRE-ROPE TRACTION.

Traction by a continuously moving wire-rope has many points in common with an electrical system on the continuous conductor principle, and the efficiency of the two methods can be readily compared. In a comprehensive review of the working of the cable tramways in San Francisco, Mr. Hanscom* gives the following results obtained from careful measurements on seven different lines :—

Total indicated power of engines	798·7 h.p.
Total power absorbed in moving the cables	548·2 ,,
,, ,, ,, cars and passengers	250·5 ,,

Hence on the average 32 per cent. of the total indicated power is available for moving the cars and passengers. Now, in comparing this with the results obtained on the Bessbrook line, it must be remembered that a portion only of the net power developed by the motor is available for moving the cars, part being required for moving the motor and its carriage. About 3·5 tons of the total of 28·6 tons represents the dead weight, and hence about 88 per cent. only of the net power is available for moving the effective load. Again, if for water-power steam-power were substituted, about 15 per cent. of the indicated power would be available for driving the generator dynamo. Hence, the ratio of the power available for moving effective load to the total indicated power would be 54 per cent. as against 32 per cent. on the cable system.

In instituting the above comparison, both systems may be considered to be working under conditions calculated to favourably develop the characteristic features of each. The grades on the San Francisco lines are in cases as steep as 1 in 6, and 1 in 10 is not uncommon. On such lines any system of electrical propulsion, except, perhaps, by a geared locomotive, would be entirely inapplicable. On the other hand, the wire-rope system would present less favourable comparative results, if applied to a line similar to the Bessbrook line, where the gradients are less severe. The paper is accompanied by a series of drawings, from which Plate 1 and the Figs. in the text have been prepared.

APPENDIX.

Cost of Construction.

The cost of the electrical equipment of the line may be briefly summarised as follows :—

	£	s.	d.
Turbine, pentrough, and driving-gear	£330	0	0
Two generator dynamos, measuring instruments, and driving belts	450	0	0
Conductor, at £200 per mile	600	0	0
Two locomotive cars, including their entire electrical equipment	1,120	0	0
	£2,500	0	0

Each of the above items include delivery and erection.

Cost of Working.

The cost of haulage was carefully ascertained over a period of five months from November 21st, 1885, to April 22nd, 1886.

	£	s.	d.
Wages of driver and attendant at generator station	£32	7	6
Sundry repairs	6	1	0
Oil, grease, and waste	5	4	10
Rental of water-power	59	16	0
Dynamo brushes, renewals of driving-chain, and commutators	14	11	6
	£118	0	10

Train-mileage, 8,652.
Hence cost per train-mile, 3·3d.

For the six months ending June 30th, 1887, during which period there had been a goods traffic of 8,000 tons over the line, a much larger amount than in the period referred to above, the cost per train-mile was somewhat greater, as follows :—

	£	s.	d.
Wages	£50	18	0
Sundry repairs and alterations, including the cost of changing the winding of four armatures of the dynamos	34	14	3
Oil, grease, and waste	10	0	0
Rental of water-power	71	15	0
Dynamo brushes and sundry renewals	12	5	10
	£179	13	1

Train-mileage, 10,176.
Hence cost per train-mile, 4·2d.

The above figures do not include anything for depreciation or for general supervision.

* "Cable Railway Propulsion," by W. W. Hanscom. Transactions of the Technical Society of the Pacific Coast, 1884, vol. i., p. 63.

TABLE I.—*Results of Integration of Curves, Plate 1, Fig 1.*

Total water-power	30·4	h.p.-hours.
,, electrical-power developed by generator	18·1	,,
Net power of motor	12·6	,,
Loss in generator	1·68	,,
,, line resistance	1·82	,,
,, leakage	0·71	,,
,, motor	2·07	,,
Sum of electrical losses	6·31	,,

TABLE II.—*Results of Integration of Curves, Plate 1, Fig 2.*

Total water power	20·63	h.p.-hours.
,, electrical-power developed by generator	10·86	,,
Net power of motor	7·82	,,
Loss in generator	0·88	,,
,, line resistance	0·65	,,
,, leakage	0·52	,,
,, motor	0·90	,,
Sum of electrical losses	2·95	,,

TABLE III.—*Results of Integration of Curves, Plate 1, Fig. 3.*

Total water-power	13·9	h.p. hours.
,, electrical-power developed by generator	4·71	,,
Net power of motor	3·62	,,
Loss in generator	0·40	,,
,, line resistance	0·14	,,
,, leakage	0·39	,,
,, motor	0·165	,,
Sum of electric losses	1·1	,,

TABLE IV.

—	First Journey.	Second Journey.	Third Journey.
	Tons cwts. qrs.	Tons cwts. qrs.	Tons cwts. qrs.
Gross load	28 12 3	21 18 0	8 16 0
Mean speed in miles per hour	5·7	7·2	11·3
Total energy of water in foot-lbs.	60,291,000	40,860,600	27,522,000
Total electrical energy developed by generator in foot-lbs.	35,871,000	21,516,000	9,332,400
Net mechanical energy developed by motor in foot-lbs.	24,928,200	15,493,500	7,170,900
Sum of electrical losses in foot-lbs.	12,493,800	5,841,000	2,174,700
Loss in generator in foot-lbs.	3,343,000	1,735,800	801,900
,, leakage ,,	1,420,300	1,029,600	775,500
,, resistance of line in foot-lbs.	3,613,500	1,296,900	287,100
,, motor in foot-lbs.	4,098,600	1,791,900	326,700
Total work done against gravity	11,867,400	7,356,800	2,858,300
Total work done against friction	13,060,800	8,136,700	4,312,600
Mean tractive force, exclusive of gravity in lbs. per ton	28·9	27·4	37·1

TABLE V.—PERCENTAGES.

—	First journey.		Second journey.		Third journey.	
	Of the water-power.	Of total power of generator.	Of the water-power.	Of total power of generator.	Of the water-power.	Of total power of generator.
Water-power	100·0	...	100 0	...	100·0	...
Generator-power	59·5	100 0	52·6	100 0	33·9	100 0
Net motor-power	41·3	69·4	37·9	72·0	26·1	76 8
Loss in generator	5·5	9·3	4·2	8·0	2·9	8·6
,, leakage	2·3	3·9	2·5	4·8	2·8	8·3
,, line resistance	6·0	10 6	3·2	6·0	1·0	3·1
,, motor	6·8	11·4	4·4	8·3	1·2	3·5

THE MAXIMUM EFFICIENCY OF INCANDESCENT LAMPS.*

BY JOHN W. HOWELL.

The word efficiency, when applied to an incandescent lamp, is used to designate the amount of energy required by the lamp for the production of a given amount of light; thus we say that a given lamp has an efficiency of 3 watts per candle, at 16 candles, meaning, that to produce an illumination of 16 candles we must supply the lamp with 48 watts.

* A paper read before the American Institute of Electrical Engineers, April 10, 1888.

The word efficiency, when applied to a prime mover or to any piece of apparatus that changes energy from one form to another, or which transmits or utilises energy, has a well-defined meaning, and is used to represent the ratio of the energy of the useful effect produced by the apparatus to the energy necessarily supplied to the apparatus to enable it to produce that effect.

An incandescent lamp transforms electrical energy into heat and light, so the use of the word efficiency to denote the watts per candle required by the lamp is not a proper one. To denote properly the efficiency of an incandescent lamp, we must be able to separate the energy of the light produced by it from the energy of the heat produced. Then the ratio of the energy of the light to the electrical energy required by the lamp will be a correct expression for the efficiency of the lamp, and we will have to find some other word to designate the watts per candle. In this paper the word efficiency is used in its ordinary improper sense to denote the watts per candle required by a lamp when producing a given amount of light.

The efficiency of a lamp varies with its candle-power. The curve, Fig. 1, shows the rate of this variation for a particular lamp. At five candles this lamp has an efficiency of 6·7 watts per candle; at ten candles it is 4·2 watts per candle, and at 20 candles it is 2·66 watts per candle.

Any statement regarding the efficiency of a lamp must, therefore, be accompanied by a statement of the candle-power at which it has the stated efficiency; without this it is meaningless. There is nothing in an incandescent lamp itself that fixes its proper efficiency or in any way indicates what it is. The lamp, from which the curve, Fig. 1, was determined has, within the limits of the curve, any efficiency between 2 and 7 watts per candle. Thus, by simply

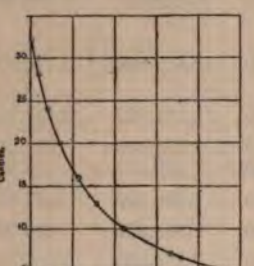


FIG. 1.

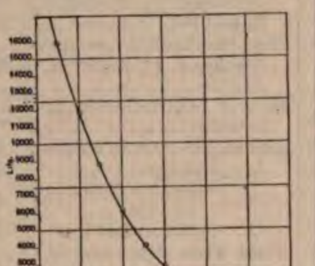


FIG. 2.

changing the candle-power of the lamp, we can operate it at any efficiency we choose, and get as much or as little light per watt as we choose.

In commercial practice the candle-power of lamps is always marked on them, and their efficiency at this candle-power is stated; but even this is not a proper index to the value of the lamp or to its proper efficiency. Experience has shown that lamps are almost universally run above their normal rating; lamps rated at 4·5 watts per candle are usually run at from 3·5 to 4 watts per candle, and in order to make lamps that will stand the strain of being run above their rated capacity, it is necessary to rate them considerably below the efficiency at which they will give the best results under ordinary circumstances.

Lamps have been made and sold in England which have a very high-rated efficiency, but parties buying these lamps are told that they will get very much more satisfactory results if they run the lamp *below their rated capacity*. So we see that some lamps are rated above their capacity and some are rated below, and the rated efficiency of a lamp is not always the best efficiency at which to run it. How, then, are we to determine the efficiency at which a lamp will give the best results? It is this question which I will attempt to answer.

The term "maximum efficiency" of a lamp, as used in the title of this paper, does not mean the highest efficiency at which a lamp can be operated, but the efficiency at which the best results are produced by the lamp; or more accurately, *the efficiency at which the cost of operating the lamp is a minimum.*

Taken in this latter sense, the maximum efficiency of a lamp is not its highest efficiency. As we increase the candle-power of a lamp, its efficiency increases; consequently, by running the lamp high enough, we can make its efficiency so high that very little power is required to produce a given amount of light, and the cost of the power to produce the light is very small. But, while the efficiency of the lamp increases, its life decreases, and if we run a lamp at too high an efficiency the saving in the cost of power is more than balanced by the increased cost of lamp renewals.

To determine the maximum efficiency for lamps under given conditions, we must determine the efficiency at which the sum of the costs of power and lamps is a minimum, and in order to do this we must know the rate of variation of the life of a lamp with its efficiency.

The curve, Fig. 2, shows this rate of variation. This curve is the result of very carefully conducted experiments made by the Edison Company. These experiments extended over five years, and consumed a very large number of lamps. Its accuracy when applied to Edison lamps is beyond question; but our experiments with lamps having an artificial surface on the carbon, or "flashed" lamps as they are called, show that their rate of variation of life and efficiency follows a different curve.

This curve does not apply to individual lamps. If we take two Edison lamps and burn them at different efficiences, their lives for these efficiencies will probably not be such as indicated by the curve, nor will they be proportioned to these indicated lives. But if we take one hundred lamps and burn them at one efficiency, and another hundred equally good lamps and burn them at another efficiency, the average lives of the two sets will be proportional to the lives indicated by the curves for these two efficiencies.

In order to determine at what efficiency the cost of operating lamps of a given quality under given conditions is a minimum, we must calculate what this cost is at different efficiencies. To do this we consider the total cost

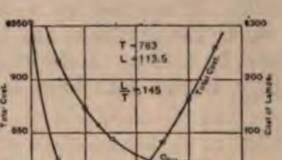


FIG. 3.

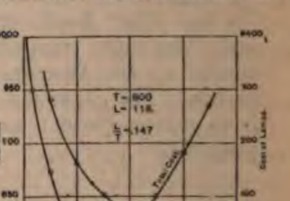


FIG. 4.

of operating the lamps to be made up of two parts—viz., the cost of the *current* and the cost of the *lamps*. The cost of the current is made up of every expense incurred in operating the lamps, including materials consumed, labour, taxes, insurance, rent, and every other expense incurred in operating the plant, except the cost of lamps. The cost of the lamps is an item by itself, and is the amount which the lamp has cost when it is put in use. This is a natural division of the total cost of operating a plant, since to produce light by incandescence, all that is necessary is a lamp and current to operate it.

If in any case we know the cost of the current required to operate the lamps, the cost of the lamps, the quality of the lamps—that is, the life they will give when burned at a given efficiency—and the rate of variation of their life with efficiency, we can then calculate at what efficiency the cost of operating the lamps is a minimum, and this I call the maximum efficiency of those lamps.

The following examples show what this maximum efficiency is under varying conditions of the cost of lamps, the cost of current, and the quality of the lamps. The cost of the lamps I have varied between 25 cents and 1·00dols. each. The cost of current varies between 2·5 cents and 10 cents per horse-power per hour. The quality of the lamps varies between 300 hours' life at 3 watts per candle, and 2,400 hours' life at 3 watts per candle.

In each of the following cases I have calculated the cost of operating 100 16-c.p. lamps 1,000 hours at each of the efficiencies comprised in the curve of total cost. These curves do not show the cost of running the same lamps at different efficiencies, but the cost of running equally good 16-c.p. lamps of the different efficiencies.

rst case we will consider is shown in the diagram In this case the lamps are assumed to cost 85 cents d to have a life of 600 hours at 3 watts per candle. rent is assumed to cost 10 cents per horse-power

ost of the current is determined from the following —

nt cost =

$$\frac{\text{:.} \times 16 \times 100 \times 1{,}000 \times \text{cost of ct. per h.p. per hour}}{746}.$$

he cost of lamps from this formula—

$$\text{st of lamps} = \frac{\text{cost of one lamp} \times 100 \times 1{,}000}{\text{Life at given efficiency}}.$$

urve marked *total cost* shows the total cost of run-) 16-c.p. lamps, 1,000 hours, the efficiencies of the arying between 2·5 and 4·25 watts per candle.

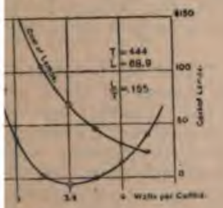


FIG. 5.

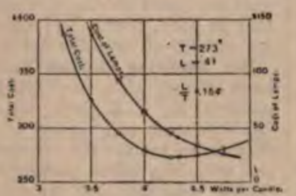


FIG. 6.

iencies are shown by the vertical lines, referring ale at bottom. The value of the total cost at any the curve is shown by the horizontal line through t referring to the scale at the left of the diagram. west point of the curve shows the point where the t is lowest. This is the minimum cost of operating nps under the given conditions. The mark at the oint of the curve shows this minimum cost to be , and a vertical line through this point to the bottom of the diagram shows that this total cost is um when lamps having an efficiency of 3·1 watts lle are used.

the maximum efficiency of these lamps under the ns assumed is 3·1 watts per candle.

amps considered in the case shown in Fig. 4 cost .; all other conditions are the same as in the wn in Fig. 3. This increases the total cost from to 800dols., and necessitates using lamps of 3·18 er candle instead of 3·1, to make the cost of g a minimum.

e case shown in the diagram, Fig. 5, the current ents per h.p. hour; the other conditions are the in the case assumed in Fig. 4. The minimum total his case is 444dols., and to make this cost a mini- must use lamps having an efficiency of 3·5 watts le.

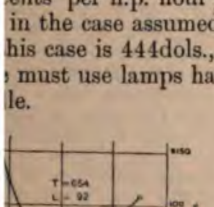


FIG. 7.

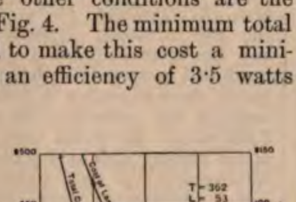


FIG. 8.

is case, shown in Fig. 6, the lamps cost the same as st, but are only half as good; the current costs just uch as in the last case. The minimum total cost in is 273dols., and the maximum efficiency of the 4·32 watts per candle.

case shown in Fig. 7 the lamps cost 50 cents, and ife of 1,200 hours at 3 watts per candle. The cur- s 10 cents per h.p. per hour. This is the cheapest the best lamp we have yet considered, but the xpensive. In this case the minimum total cost is , and the maximum efficiency of the lamps is 2·62 er candle. In this case, Fig. 8, the current costs uch as in the previous case, other conditions being e. The minimum total cost is reduced from to 362dols. The maximum efficiency in this case vatts per candle. In Fig. 9 the current costs twice as in the previous case, and the lamps are only half as good. The minimum total cost is doubled, but the maximum efficiency is the same as in the previous case.

In this case, Fig. 10, the current costs one-half of that assumed in the previous case, other conditions being the same. The minimum total cost is 400dols., and the maximum efficiency 3,175 watts per candle.

The curve, Fig. 11, illustrates the case of very cheap and very good lamps, with moderate cost of current. The minimum total cost is low, 294dols., while the lamps are run at the high efficiency of 2·38 watts per candle.

In the case shown in Fig. 12, the cost and quality of the lamps are the same as in the previous case, but the current costs twice as much. This increases the minimum total cost from 294dols. to 535dols., and raises the maximum efficiency to 2·14 watts per candle.

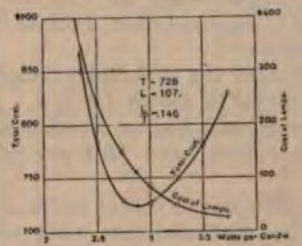


FIG. 9.

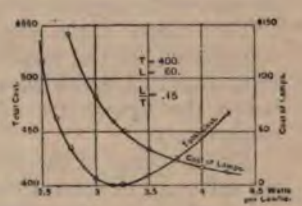


FIG. 10.

In the case, Fig. 13, the cost of lamps and the cost of current are the same as in the case shown in Fig. 11, but the lamps are only half as good. The minimum total cost is increased from 294dols. to 327dols., and the maximum efficiency is reduced from 2·38 to 2·62 watts per candle.

The first and plainest inference drawn from these curves is that the maximum efficiency of any given lamp is not a fixed one, but varies with conditions outside the lamp itself. Identical lamps operated under different conditions of cost of current must be burned at different efficiencies to make the cost of operation a minimum for the production of a given amount of light. In order to determine the maximum efficiency of lamps, therefore, we must know the quality of the lamps referred to some standard, the cost of the lamps to the consumer, and the cost of current under the actual conditions existing at the place where the lamps are to be used.

In the eleven cases shown in this paper the lamp of highest efficiency is obtained in the case shown in Fig. 12. This is a case where the lamps are very cheap and very good, and current is very expensive. The lamp having the lowest efficiency isobtained in the case shown in Fig. 6, in which the lamps are poor and high-priced, and the current is very cheap.

There is a marked difference in the sharpness of these curves at the minimum points. An inspection will show

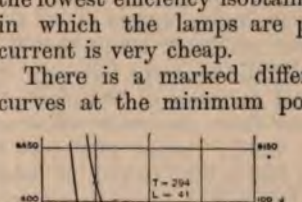


FIG. 11.

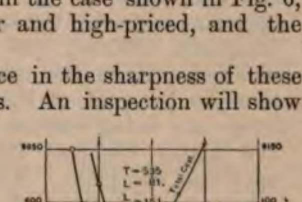


FIG. 12.

that the sharpness of the bend in these curves depends upon the cost of the current, the curves in which the currents cost 10 cents per h.p. per hour being the sharpest. Those in which the current costs 5 cents are next, and the one, Fig. 6, in which the current costs only $2\frac{1}{2}$ cents per h.p. per hour, is very flat at the bottom or minimum point. In this comparison Fig. 7 is not considered, as it is drawn on a different scale from the others, and is not as sharp as it should be.

This indicates that the more expensive the power is, the more carefully must the lamp efficiencies be chosen. In Fig. 12, which shows the sharpest curve, a very slight variation in the efficiencies of the lamps makes a very great change in the total cost of operation. In the case shown in Fig. 6, in which the current is very cheap, we find that a very considerable change in the efficiency of the lamps used makes very little difference in the total cost or operation.

On each of the eleven diagrams two curves are drawn, one showing the total cost of operation, and the other showing the cost of lamps. On each of the curves showing the cost of lamps a point is marked which indicates the cost of the lamps when the total cost is a minimum. The letter T, marked on each of the figures, denotes the minimum total cost of operating the lamps under the given conditions. The letter L denotes the cost of the lamps when the total cost is a minimum; and the expression $\frac{L}{T}$ denotes the ratio of the cost of lamps when the total cost, is a minimum, to the minimum total cost. An examination of all these curves shows that while the minimum total cost varies with each of the three quantities—price of lamps, quality of lamps and cost of current—nevertheless, *the total cost is always a minimum when the cost of lamps is about* 14·5 *or* 15 *per cent. of the total cost of operation.*

This figure varies somewhat in the different examples considered, but the variation seems to follow no law. In Figs. 6 and 12, which show the highest and lowest efficiency lamps, the figures are 15·1 per cent., and 15·4 per cent. respectively.

The steepness of the curve showing the cost of lamps, and the difficulty of determining the exact minimum point of a curve which has been drawn by inaccurate methods, makes it difficult to get the cost of lamps accurately when total cost is a minimum. These curves and values are given just as they were determined, and no effort has been made to bring the results into closer agreement, as could readily have been done. I consider the variation shown by these curves to indicate closely enough that this ratio of cost of lamps to total cost at the minimum point is nearly, if not quite, constant, and that its value is between ·145 and ·15.

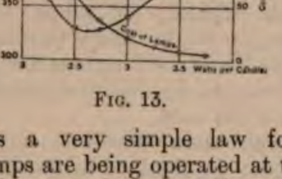


Fig. 13.

This establishes a very simple law for determining whether or not lamps are being operated at their maximum efficiency; for if they are, the lamp bills will be about 15 per cent. of the total operating expenses of the plant. If the lamp bills are more than 15 per cent. of the total operating expenses, the lamps are being burned above their maximum efficiency, and lower efficiency lamps should be obtained. If, on the other hand, the lamp bills are less than 15 per cent. of the total expenses of the plant, the lamps are being burned below their maximum efficiency, and higher efficiency lamps would reduce the cost of operating the plant. Where fuel is high priced, or where other causes operate to make the cost of generating current high, it is specially important to use lamps of the maximum efficiency; for we have seen from the above curves that where the cost of current is high, the use of lamps whose efficiency is a little above or below the maximum efficiency attainable under the conditions of operation makes a very marked increase in the operating expenses of the plant.

If in any plant the lamp bills are only 10 per cent. of the total expenses, then *increasing the efficiency of the lamps by increasing their candle-power does not diminish the total cost of operating the plant.* In order to reduce the total cost, *the lamps must be replaced by lamps of the same candle-power, but of higher efficiency.* If the efficiency of the lamps is increased by raising their candle-power, the cost of operating the plant *per unit of light produced* is reduced, but the total cost is increased. A plant which is paying less than 15 per cent. of its total expenses for lamps, and which brings the lamp-bills up to 15 per cent. by increasing the candle-power of the lamps, does not decrease the cost per lamp of operating the plant, but *does* decrease the cost per candle of light furnished. If they are paid for the increased light given by the lamps, the efficiency of the plant is made a maximum for the existing conditions; but if they are not paid for the additional light furnished, the efficiency of the plant is reduced.

This law enables anyone operating an incandescent lamp plant to determine whether or not he is using the most suitable lamps for his plant. If the conditions of operation of a new plant are all known, and the quality of the lamps made by any lampmaker is known, we can determine before starting what is the most economical lamp to use.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

An ordinary general meeting of this society was held on April 26, Mr. E. Graves, president, being in the chair.

In opening the proceedings **Mr. Graves** referred to the recent death of Mr. T. R. Crampton, who, he said, had been a member of the society for many years, and who was specially known for the service he had rendered to electricity in first introducing the type of submarine cable, that was used for the first successful cable between Dover and Calais laid in 1851, which had continued to be used up to the present day and existed all over the world.

Sir Douglas Galton moved: "That the members of the society have learned with deep regret the decease of their much-esteemed member, Mr. T. R. Crampton, who was intimately connected with the establishment and laying of the first successful submarine cable, and they desire to offer the expression of their sympathy with his widow and with the other members of his family on the loss they have sustained," and said that Mr. Crampton was a born engineer, and besides introducing the type of submarine cable which had been so universally adopted, had introduced a form of locomotive which still held its place on several railways in France.

The motion was seconded by **Prof. Forbes**, and unanimously carried.

CENTRAL STATION LIGHTING—TRANSFORMERS v. ACCUMULATORS.

The adjourned discussion on Mr. R. E. Crompton's paper, on "Central Station Lighting—Transformers v. Accumulators," was resumed.

Mr. W. B. Esson said that Mr. Crompton's paper would have been much more valuable had he confined his attention solely to the experience obtained at Vienna, instead of adopting figures expected to be obtained from a hypothetical case. Accumulators, so far, had not given a return higher than 60 to 61 per cent., and seeing that they required a charging force of 2·5 volts, and only discharged 2 volts, it was highly improbable that in actual practice they ever gave more than 70 per cent, if, indeed, that figure was ever reached. He would not like to put down mains to distribute from four centres, at an aggregate of 600 volts, at the price mentioned by Mr. Crompton, if he had the Bank of England at his back. He agreed with Mr. Crompton that the cost of alternating current dynamos would be more than the £5,000 or so that he had put down. Calculations that he had made brought out the total of £7,500, but the type might be improved and cost less in the future. In working expenses he thought there was little to choose between transformers and secondary batteries. They had no figures yet of the actual cost of an alternating current transformer system, and he wished that those who were interested in its working would show their coal bills. As to reliability, also, he thought there was very little to choose between the two systems. Dynamos might break down in either case, and the remedy for that was to have a spare reserve ready. Too much had been made of the reliability of the accumulator. As to the mains, there were two systems of distribution before them—one by mains at low potential, 100 volts, and the other at high potential, 2,000 volts. He would view with distrust any ramification of mains placed underground having the high potential of 2,000 volts, and when transformers were used which distributed the current at 100 volts the cost of distribution would be about the same as Mr. Crompton put down for accumulators. The cost of the main for charging accumulators was much larger than the cost of alternating transformer mains, some six or eight times as large, and that was the only material difference in the two systems. He had before referred to the use of continuous current transformers, and had pointed out how very easily they could be used in conjunction with accumulators, and he hoped some one would remark upon that later on.

Prof. G. Forbes, F.R.S.: I think that the paper which has given rise to this discussion is of a character which ought not generally to be read before the society. It is unfortunate that a paper should be given based merely upon a hypothetical case instead of upon accomplished facts. The discussion has taken the form of a general discussion upon the distribution of electricity. I am very sorry that Mr. Crompton is not here to-night, as I particularly wish him to hear what I have to say. It is extremely unfortunate that he did not give us a paper upon the installation which he tells us has been successfully worked, and which would bear out the results of the paper itself. He would have been able to give us some information about the action of the accumulators used at Vienna and Kensington, about the amount of current put into them, the amount taken out, and a great deal of other valuable information. He may say that we can judge for ourselves from the Howell accumulators at Kensington, and that we have every facility for doing so; but I have never been able to find the means of determining the value of an accumulator from simply looking at it while working at a central station. Instead of discussing the various other methods alluded to at the beginning of his paper, he has selected one, as it happens, the least advantageous—that of accumulators. But if he proved his case in this instance he has not proved the previous assertion—that he sees no special advantages of transformers over "other methods," because he has merely taken the single case of a

small station with 10,000 lights at a distance of 2,000 yards. It does not follow that transformers would not be the more useful in a larger station with a greater number of lights. If he had gone into the figures of the numerous other systems, there is not the slightest doubt, in my mind, that the system—which is neither the accumulator nor the transformer system—found most economical, would be the Stanley system mentioned in Mr. Mackenzie's excellent paper read a short time ago. As an example of the cost of these different systems of distribution, I may mention the work which I did two years ago after I had published the theoretical work. I took the special case, in London, of the club district of Pall-mall, St. James's-street, and St. James's-square. I got information from all the secretaries of the different clubs as to the number of hours of lighting the different rooms, the number of lights in each room, and everything. I devoted a considerable length of time, with the assistance of Mr. W. H. Snell, to working out the cost of the different systems, and I will give the results arrived at. The cost per candle-power per annum was, with the simple parallel system, 2s.; the 2-wire system, 1s. 10½d.; the multiple-series system, 1s. 10d.; the multiple-series system complying with the Board of Trade regulations, about 200 volts difference of potential, 2s.; the simple-series system, like Mr. Bernstein's, 1s. 10¾d.; the secondary generator system, 1s 10½d.; and with secondary batteries, 1s. 4d. The chief points in Mr. Crompton's paper are the two tables showing the cost of the installation and the cost of maintenance. There are distinct errors in them, and I will point out the errors which produce the fallacy of the results arrived at. In Table III. 600 kilo-watts are given as the maximum. I cannot do better than illustrate my remarks on this paper by mentioning the practice in America which I have had opportunities of examining in all the details in the last few months. It is found most positively that the return of the Westinghouse transformer is more than 600 kilo-watts in the lamps for the indicated horse-power. Mr. Crompton, for a 600 kilo-watt station, has demanded 1,450 h.p., instead of 1,000 h.p.—that is to say, he has added 50 per cent. on to the actual power required as a maximum. That, he would say, was intended for reserve; it is enormously beyond what the reserve requires. Reducing those figures to their proper dimensions also reduces the cost of generating station, buildings, chimney shaft, water tanks, and general fittings, taken for the alternating transformer system at £11,000, and for the accumulator system at £8,000. The cost of dynamos and exciters is correct, in accordance with the American figures, including station switches, resistance-boxes, voltmeters ammeters, lightning arrester, compensators, synchronisers, and spare armatures, ball bearings and brushes. The price of transformers is given as £7,500, instead of £4,000. The mains are the point on which Mr. Crompton has made the greatest error. He has not appreciated the value of the transformer system in economising mains. In his proposed scheme he proposes £20,400 and 22,000 yards of underground mains for a wretched station of 10,000 lights. These charging mains which carry the current carry only 300 amperes at the maximum, and are we going to dig up wooden paving and concrete, build a trough and put one conductor of ½in. diameter at the bottom of it? It is simply absurd that we should take a case like that as illustrating the way in which the transformer system should be applied. If we are to put down such a small station under these conditions, it most undoubtedly ought to be by overhead wires; but then immediately the cost falls down enormously. But with the other systems which are at our disposal, the three-wire system and any other, the current is enormous, and is not anything like 300 amperes, and it would be impossible to put a single conductor carrying that current overhead. Even in Mr. Crompton's case, in which he is using a potential of 480 volts—a potential which he is not allowed to use in this country, which he cannot use—the current which he is carrying is 1,500 amperes, and he is using conductors whose sectional area is 2·55in. You cannot have wires like that slung all the way overhead. Such massive conductors must be put underground, and still more would it be necessary if a system complying with the Board of Trade regulations were adopted. Consequently, I reduce Mr. Crompton's calculations for the mains in the alternating system to £6,000. Thus, I find that the total cost of the alternating transformer system for the proposed case is £39,140 instead of £57,440, and thus we have the comparison between the alternating and accumulator systems, the cost for the latter being, if we accept Mr. Crompton's figures on all points as being correct, £59,762. Having pointed out the sources of error in dealing with the alternating current system I will now point out what are the sources of error in connection with the accumulator system which are sufficient to throw doubt upon the accuracy of these results as regards efficiency. For the combined efficiency of the conductors and accumulators Mr. Crompton says that "for the output of 2,100 units it will be sufficient to work the generating plant for about five hours at approximately its greatest rate of efficiency. I have had ample experience with this class of plant, and know that we can actually in practice produce the electrical h.p. at the terminals of the dynamos with the expenditure of 3½lb. of coal." Good, granted. "Taking the maximum loss in the accumulators, the efficiency of the system—that is, the electrical h.p. at the lamps divided by the electrical h.p. at the terminals of the dynamos—will be not less than 80 per cent.: therefore we may say that each unit at the lamps can be produced for 5·75lb. of coal"—a Board of Trade unit for 5·75lb.—that is, 4·31b. of coal per h.p., which is simply 20 per cent. added on to the 3½lb. of coal; 3½lb. of coal for the work given out at the terminals of the dynamo, and only 20 per cent. loss over the whole of the conductors; and that is taking into account the working of the batteries as well. He has told us in the paper that he will admit a loss of 10 per cent. in his charging-mains, and 4 per cent. in his distributing mains, making 14 per cent. As a matter of fact, I have worked it out, and I find that his charging-mains have a loss of 12 per cent. instead of 10 per cent., which will make 16 per cent. altogether. I do not know how his distributing-mains are worked, and must accept his 4 per cent. for them—that is, 16 per cent. out of the 20 per cent. is due to the charging-mains, and 4 per cent. loss in the efficiency of the accumulators, assuming that he employs accumulators giving an efficiency something like 96 per cent!—Mr. Crompton also tells us that the average rate at which the accumulators are to be able to discharge is 416 amperes for five hours, giving a capacity of 2,080 ampere hours; and they are also to be capable of the very rapid discharge at an efficient rate—the enormous rate of 1,352 amperes. In his final table of the working of accumulators, he puts the depreciation down at 15 per cent. I know of no company who will furnish accumulators and work them at that rate of maintenance. Mr. Preece has told us that with the cells used for lighting his house, which are carefully attended to, and which have 16lb. active material, there is 1lb. of the active material lost in the first year. At what rate the loss goes on in subsequent years, or how many years it takes to destroy the cell, I cannot say; but I am perfectly certain that a 15 per cent. depreciation is not sufficient. I am perfectly certain that if Mr. Crompton had given us the actual facts gained at Vienna and Kensington, the results would have been totally different from what he has claimed in the paper. He says, "Up to a recent date far too much attention has been paid to the capacity, and too little to the rate of possible maximum discharge. This state of things has lately been remedied, and I am told there are several makers of accumulators, who can supply them to fill the above-mentioned conditions, and at the reasonable price, named by me in my estimate," of £40 per cell. That is simply rumour—he has been told it. Likewise, the facts stated for the alternating current system are stated to have been simply from hearsay information, because, he says, "For the purposes of my comparison, I take the system as generally described by Mr. Kapp in his paper on transformers, or by Mr. Mackenzie in his paper on transformers, and in an article in *Industries* dated December 7th, 1887, for which, I believe, Mr. Kapp is responsible, and which gives very complete data on the first cost of an installation for 10,000 60-watt lamps burnt simultaneously." Thus, undoubtedly, the want of practical experience with the alternating-current system is the reason why he has fallen into the errors I have pointed out. I am sorry to see that in the early part of his paper Mr. Crompton made a statement to the effect that the experience which has been gained in America and in other places with the alternating-current system "does not help us much in our investigation." I should say that it would help us infinitely more than the reading of any number of papers he may have laid hands on. I say that in the few months I have been studying the system in America I have gained more practical information, such as is applicable to either such a station as Mr. Crompton has taken, or to any other, than I could have obtained from reading the papers of all the authors who have written in this country on the subject. Before leaving the question of estimates I would refer to Mr. Crompton's remark that "a great deal of nonsense has been talked about the cost of conductors being proportional to the cost of copper." I dare say that may be so, I do not remember it; but do not let us talk any more nonsense on the subject. He says that his tables are sufficient to show that we must not consider the cost of laying the conductors as in any degree proportional to the cost of copper. I say that in overhead wires you must consider that it is so, and, while I would not wish to see overhead wires laid for a really large installation, still, in a small installation of 10,000 lights, I think they ought to be laid When I have previously dealt with the question of distribution I have dealt with an installation of 100,000 lamps, and that is the size which I hope we shall have to deal with in a town having a population of 4½ millions. Now, let us look at Mr. Crompton's table No. 2, showing the cable dimensions and the cost of laying them. There the cost of laying small cables is out of all proportion to the cost of the copper, but when you come to a cable of 3in. section the cost of laying becomes gradually very small compared with the cost of the copper, and the cost of the copper and its insulation, when cables capable of carrying the high current required to supply 100,000 lights are required, is nearly equal to the cost of laying. It may be taken as absolutely assured that the cost of copper is roughly proportional to the cost of laying. As indisputable proof of the accuracy of his figures, Mr. Crompton says he is prepared to lay down an accumulator system, such as he supposes, at the cost put down for it. He may be, but he will not have the opportunity, as it is not allowed in this country. I know plenty of people who are perfectly willing to lay down an alternating-current system to supply such a district for the figure he has given, £57,440. It is perfectly certain that that can be done. Here my criticism of Mr. Crompton's paper ends. I intend some time to give somewhere a full account of the alternating-current system as used in America, and I had thought some account of it might have been interesting here to-night. Perhaps I may take up a few minutes longer of your time for that purpose. One fact occurs to me as bearing upon Mr. Crompton's estimate for attendants at the central station. The cost of keeping up a central station in America struck me from a commercial point of view more than anything else—there being few men, and a small amount of labour and supervision employed. Denver, with a capacity for 7,000 lamps, retains one manager at $150 a month, a secretary at $80 a month, and an office boy; it has two dynamo attendants, five firemen, two inspectors who go over the lines, and one repair man. That is a station where coal is used. At Pittsburg, Alleghanny, and East Liberty, coal is not used, but natural gas. At such stations one solitary man attends to the whole of the boilers for a 10,000-light plant. The natural gas and air to be consumed are let in through pipes controlled by a valve, which is regulated by the pressure of steam in the boilers. Westinghouse engines are chiefly used, and they are fairly, though not very, economical. They give but little trouble, and the governor, which runs in an oil bath, is extremely sensitive. The dynamo machines are of quite a different form to those hitherto used in this country. I presume we have now given up the use of alternating dynamos that have no iron in the armature. There is no doubt that the iron in the armature is the essential feature of a good alternating-current dynamo. The Westinghouse machine consists

of a large outside ring attached to the framework, with pole-pieces projecting inwards. The armature is of the drum form, and consists of a large number of thin sheets of metal; it is wound in a special way. The machine is mechanically and electrically excellent. The heating is very little indeed, and the exciting power is 2 per cent. of the total power developed. Three types of machine only are made—650-light, 1,300-light, and 2,600-light. The number of revolutions per minute for the larger machine is 1,000 per minute, the resistance of the armature ·15 ohm, and the weight 18,000lb. Much progress is being made with the Parson's generator, which is likely to become one of our economical machines. In testing the converters at Mr. Westinghouse's works at Pittsburg, I adopted the calorimetric method described here some time ago by Prof. Ayrton, and which has been used by M. Rouïti with the Gaulard-Gibbs apparatus, and from a 30-light machine with a half load I got 95 per cent. My time is now up, but I would say a word about the manufacture of dynamos and converters at Mr. Westinghouse's establishment. Only three types of dynamo and five types of converter are made. To make a single converter ten different machines have to be employed, each of which is capable of turning out its parts at the rate of from 50 to 100 per day, and by using such machines, which are always ready to turn out exactly to scale, the apparatus can be supplied at an extremely low figure. The parts of such machines are all interchangeable, consequently, if a part fails, another can be telegraphed for immediately. Some of the smaller parts of the Westinghouse system of distribution are now on the table. The central station switch-board used in America is smaller and compact, compared with the gigantic things used in this country. I have also placed on the table a specimen of the MacIntyre form of joint which is used for joining wires.

(To be concluded.)

COMPANIES' MEETINGS.

EASTERN EXTENSION COMPANY.

The 29th ordinary general meeting of the Eastern Extension, Australasia, and China Telegraph Company, Limited, was held on Wednesday at Winchester House, Sir John Pender presiding.

The **Chairman** stated that the net revenue had been £117,889, or £26,819 more. For the whole year the gross receipts had been £451,861, being an increase over those of 1886 of £10,062, and the working expenses had been £145,812, or £16,029 less. An interim dividend of 1¼ per cent. had been paid for the half-year, and it was proposed to pay a similar dividend on the following day, making with previous distributions 5 per cent. for the year. They also proposed to distribute a bonus of 3s. a share, which would increase the total return for the last year to 6½ per cent., or ½ per cent more than for 1886. The balance of £53,051 had been carried to the general reserve fund, which now stood at £620,095. The completion of the renewal of the Singapore-Saigon section with brass-ribanded cable had been carried out since the close of the half-year, the cost of which, amounting to about £17,000, would be dealt with in the accounts for the current half-year. That gave them a new cable entirely brass-ribanded between Singapore and Saigon, paid for out of revenue. During the current year they purposed affecting important alterations in the Madras-Penang cable at the Nicobar Islands, and in the Java-Australian cables off the Lambok Strait. Those changes would probably cost £75,000; but it was anticipated that they would effect considerable improvement in the working, and a large saving in the cost of repairs. They had been unable to obtain a renewal of the cable subsidy from the New Zealand Government, and they had, therefore, been obliged to raise the tariff over the New Zealand cable. In that way they had nearly recouped themselves for the loss of the subsidy. Their negotiations with the Chinese Government had resulted in an agreement, and everything was complete in connection with that matter except the signature. They had since the last meeting completed an arrangement with the Netherlands-Indian Government for a cable of 462 miles. That Government would pay for the cable, which would be a feeder to the Company's system. He concluded by moving the adoption of the report and the declaration of the dividend and bonus recommended.

The **Marquis of Tweeddale** seconded the motion, which was carried unanimously.

The retiring directors and auditors were afterwards re-elected, Mr. John D. Pender being appointed a member of the Board in the place of the late Sir W. M'Arthur.

WESTERN AND BRAZILIAN COMPANY.

The 15th ordinary general meeting of the Western and Brazilian Telegraph Company, Limited, was held on Thursday, at Winchester House, Old Broad-street.

Mr. W. S. Andrews, who presided, stated that he had been elected chairman of the Company owing to the retirement of Sir H. D. Wolff, on the latter's appointment as British Minister to the Court of Persia; and to fill the seat at the Board thus vacated Lord Richard Browne had been appointed. He then congratulated them on the continued improvement in the position of the Company. As regarded the current year, too, a satisfactory increase had so far been shown in the receipts as compared with those for the corresponding period of 1887, and the increase would have been larger but for an interruption to one of the cables. The increase of £21,000 in last year's revenue compared with that for 1886 had been earned at an additional outlay of 8 per cent. After crediting the revenue fund with £15,000, and putting £10,000 to the debenture redemption fund, they were enabled to pay a dividend of 3 per cent., making 4½ per cent. for the year, leaving £3,464 to carry forward. For some time they had had before them the importance of doing something to certain sections in order further to strengthen the system. Any new cable would be obtained by tender, and for part of the cost their reserve fund would probably be appealed to. He concluded by moving the adoption of the report and the payment of the dividend mentioned.

Mr. H. Weaver seconded the motion.

In reply to questions, the **Chairman** stated that the length of the cable was 3,700 miles, and the lines were working all right from end to end. There were no negotiations now pending with the Brazilian Government.

The motion was adopted, and the retiring directors and auditor were re-elected.

An extraordinary general meeting was afterwards held, when resolutions were submitted for altering clauses 6, 7, 26, and 50 of the articles of association (removing certain features which were acknowledged to be objectionable, and providing also for the holding of half-yearly meetings of the Company); for approving an agreement between the Company and the London-Platino Brazilian Telegraph Company, and for that purpose, and other purposes of the Company, increasing the capital to £1,500,000 by creating 30,090 shares of £15 each, to rank *pari passu* with the existing ordinary shares of the Company.

Mr. Guesdon approved the proposed changes in the articles of association, but advocated further improvements in them, especially the abolition of the power of the Directors to issue stamped proxies.

The alterations in the articles having been agreed to, the Solicitor read the proposed agreement between the Company and the Platino Company.

The **Chairman** then explained that by what was proposed the two companies would be brought under a common control, with a common proprietary, though an actual amalgamation would not be effected. Of the capital of £1,500,000, about £345,000 would go to the Platino Company if all their shares were exchanged for those of the Company in the manner proposed, and 7,090 shares would remained unissued.

In the course of the discussion which followed, objection was taken to the proposal to give the Directors of the Platino Company £6,000, or shares in the Company of the nominal value of £9,000, as compensation for their loss of office.

The **Chairman** explained that it was part of the arrangement; and in the future the Directors of the Company would do the work for nothing which had hitherto been performed by the Directors of the other Company.

The resolution approving the agreement was eventually passed with 12 dissentients. The other resolutions for increasing the capital, &c., were afterwards agreed to.

INDO-EUROPEAN TELEGRAPH COMPANY.

The twenty-first ordinary general meeting of the Indo-European Telegraph Company, Limited, was held on Monday, at Winchester House, Old Broad-street.

Colonel James Holland, who presided, stated that the revenue for 1887 had been £104,290, or about the same as for 1886. The Indian messages, however, had contributed between £6,000 and £7,000 less, and it was a discouraging fact that that traffic, the tariff of which they had reduced, still remained inelastic. Fortunately, their receipts had been made up by other sources of revenue. There had again been a decrease in their expenses, which had been altogether £2,152 less than those for 1886. They had added £10,000 to the reserve fund, which now stood at £102,463, but the securities representing that fund were, at the market prices of last week, of the value of £110,775. They were carrying forward a larger balance. The cost of maintenance had been very low, but it should be remembered by the shareholders that a large outlay might have to be made at short notice. He concluded by moving the adoption of the report and the declaration of a dividend of 1s. 6d. a share, making, with the interim dividend, 6 per cent. for the year, and a bonus of £1 a share, both free of income tax, making in all 10 per cent. for the year.

Mr. J. Herbert Tritton seconded the motion.

The **Chairman**, in reply to questions, said he quite agreed that a reserve fund of 25 per cent. on the capital was a very fair amount as an ordinary rule; but there were special difficulties connected with the Company which made them think that they had not yet quite reached the amount at which the reserve fund should stand. If a war broke out in any part of Europe they would be affected, because Germany and Russia—the latter undoubtedly—would be closed to them. They hoped, if peace were maintained and trade recovered, that they might be enabled to divide more of their profits; but at the same time he could not help saying that the return they were now proposing was a very good one; and it should be remembered that the increase of the reserve fund added considerably to the market value of their shares.

The resolution was carried unanimously, and the retiring directors and auditors were re-elected.

PROVISIONAL PATENTS, 1888.

APRIL 20.

5870. **Improvements in electric batteries.** Robert Rauschke, of the firm of Mayer Meltzer and Co., Commercial-street, Halifax.

5899. **Improvements connected with ships' engine room telegraphs.** William Chadburn, 15, Water-street, Liverpool.

5900. **Improvements connected with mechanical telegraphs for use in navigable vessels.** William Chadburn, 15, Water-street, Liverpool.

5911. **Improvements in railway rolling stock and in the arrangement of switches, and of motors for electrically propelling same.** Michael Holroyd Smith, 55 and 56, Chancery-lane, Middlesex.

13. **Improvements in electric telegraph, telephone, and electric-light insulators.** Arthur West Heaviside, 7, Grafton-road, Whitley, Newcastle-on-Tyne. (Complete specification.)

22. **Improvements in connections especially suitable for joining electric conductors.** George Stuart, 24, Southampton-buildings, London, W.C.

April 21.

57. **Improved galvanic salts.** Augustus Collingridge, 97, Newgate-street, London, E.C.

April 24.

75. **New and improved method of heating by means of electricity.** Elias Elkan Ries, 11, Wellington-street, London, W.C. (Complete specification.)

76. **Electrical appliances for a mariner's compass to give alarm upon deviation from the ship's course.** Augustus Gross, 45, Southampton-buildings, London, W.C. (Complete specification.)

93. **Improvements in "Morse inker" apparatus for telegraphic purposes.** Frank Jacob, 28, Southampton-buildings, Chancery-lane, London, W.C.

00. **An improved form of locking electrical indicator.** Joseph Torr Todman, 21, Finsbury-pavement.

April 25.

53. **Improvements relating to electric arc lamps.** Frederick Richard Boardman and Francis Teagua, 71, Ondine-road, East Dulwich, London, S.E.

57. **Improvements in lanterns for electric arc lamps, and in posts or columns for supporting the same.** Richard Edwd. Keen, 45, Southampton-buildings, London, W.C. (Complete specification.)

April 26.

34. **Improvements in telephones.** Mark Ruddle, of the firm of Sanderson, Ruddle, and Co., 4, Mansfield-chambers, 17, St. Ann's-square, Manchester.

91. **Mode of preparing carbons for electric lighting.** Carl Anton Johannes Hugo Schroeder, 17, Althorpe-road, Upper Tooting, London, S.W. (Complete specification.)

4. **Improvements in laying underground electric conductors.** Charles William Farquhar, 24, Southampton-buildings, London, W.C.

SPECIFICATIONS PUBLISHED.

January 27, 1887.

53. **Improved means of oxydizing and decomposing by electrical action organic matter and inorganic salts in sewage, water, and other liquids.** William Webster, junr., 28, Southampton-buildings, Chancery-lane, London, W.C.

May 6, 1887.

32. **Improvements in and connected with electrical distribution by means of direct or alternating currents, chiefly for lighting purposes, and in electric measuring instruments which may be used therewith.** James Swinburne, Shona, Chelmsford, Essex.

May 13, 1887.

33. **An improved apparatus for signalling by electricity.** Harold Humboldt Slater, 36, Wray-crescent, Tollington-park, and Arthur Samuel Newman, 14, St. John's-square, both in Middlesex.

May 21, 1887.

26. **An improved process for the preparation of aluminium, aluminium bronze, and alloys of aluminium by electrolysis.** Arthur Charles Henderson, 46, Southampton-buildings, Holborn, Middlesex. (Paul Louis Toussaint Héroult, France.)

May 25, 1887.

8. **Improvements in electric transformers, induction coils, or inductional resistance coils.** William Morris Mordey and Charles Edmund Webber, C.B., 47, Lincoln's-inn-fields, London, W.C.

May 31, 1887.

57. **Improvements in registering meters for electric currents.** Henry Tudor, 6, Lord-street, Liverpool.

June 4, 1887.

8. **Improvements in holders for incandescent electric lamps.** Henry Bayley, 2, Bernard-street, Walsall, Staffordshire.

June 9, 1887.

4. **Improvements in the electro-deposition of the heavy metals.** Silvanus Phillips Thompson, 52, Chancery-lane, London, W.C.

June 11, 1887.

3. **A telephone apparatus without a diaphragm.** Frederick William Neale, 166, Fleet-street, London, E.C.

June 24, 1887.

1. **Improvements in the construction of dynamo-electric generators and motors.** Edward Jones, 6, Bream's-buildings, Chancery-lane, London, E.C.

October 27, 1887.

522. **An improved electric accumulator.** Ernest Edward Vaughton, 94, Trinity-road, Birchfield, Birmingham.

March 9, 1888.

3678. **Improvements in and relating to electrical signalling on railways, and in apparatus therefor.** Wybrants George Olpherts, Gray's Inn Chambers, 20, High Holborn, London, W.C.

March 20, 1888.

4258. **Improvements in station indicators.** Thomas William Munroe, 519, Seventh-street, Washington, D.C., United States.

March 24, 1888.

4561. **An improved battery jar.** Charles Alva Brown, Somerset Chambers, 151, Strand, London.

COMPLETE SPECIFICATIONS ACCEPTED.

1887.

4220. **Measuring electric currents.** W. J. King. 8d.

4447. **Measuring, &c., currents of electricity.** P. B. Elwell. 8d.

4832. **Carbon plates for primary batteries, &c.** H. Liepmann. 8d.

6028. **Miners' safety lamps.** A. Schanschieff. 8d.

1888.

3097. **Secondary voltaic batteries.** B. M. Drake and J. M. Gorham. 6d.

NEW ELECTRICAL COMPANIES.

Bournemouth Electricity Company, Limited.—Registered by Hooper and Son, 69, Ludgate-hill, London, E.C. Capital £50,000, divided into 10,000 shares of £5 each. Object: to enter into and carry into effect an agreement with Messrs. Phillips, Harrison, and Hart, of No. 2, Victoria-mansions, Westminster, electrical engineers, of the one part, and the Bournemouth Electricity Company, Limited, of the other part; to enter into and carry out contracts for lighting the town of Bournemouth with electricity, and maintenance of the same. The first subscribers are:—

	Shares.
H. Joy, landowner, Seamoor, Poole-road, Bournemouth	1
J. C. Harvey, Chasely, Bournemouth	1
J. H. Moore, architect, Southbank, Bournemouth	1
E. Dyke, merchant, Southcote-road, Bournemouth	1
J. Kilmer, hotel keeper, Highcliffe Hotel, Bournemouth	1
H. Patten, bank manager, Old Christchurch-road, Bournemouth	1
W. H. Dore, house proprietor, Bournemouth	1

The number of directors shall not be less than three nor more than twelve, and the first shall be determined, together with the renumeration, by the subscribers to the memorandum of association.

The Telephone Companies.—The United Telephone Company has, says the *Financial News*, taken time by the forelock, and has registered two companies, which are to include the whole of the telephone companies in the kingdom. The first company registered was the Telephone Union, Limited, with a capital of £10,000,000. In order to escape the new tax, which would amount to £9,000, this huge company was registered rather hurriedly, so another has also been provisionally registered with the title of the United Kingdom Telephone Company, Limited, and when the arrangements for the federation of the telephone companies are completed it will be decided which of the two is to be abandoned and which carried through. The articles of association of the second company will be signed by the chairman of the whole of the subsidiary telephone companies and by the Board of the United. The following particulars have been obtained at Somerset House of the Telephone Union, Limited:—Registered by Ashurst Morris, Crisp, and Co., 6, Old Jewry, E.C., with a capital of £10,000,000, divided into 2,000,000 shares of £5 each, with power to increase and from time to time to issue any shares of the original, or of new capital, with any preference or priority in the payment of dividends or the distribution of assets, or otherwise over any other shares, whether ordinary or preference, and whether issued or not, and to vary the regulations of the Company so far as necessary to give effect to any such preference or priority, and upon the subdivision of a share to apportion the right to participate in profits in any manner as between the shares resulting from such subdivision. Object: to acquire upon any terms, and for any purpose the whole or any part of the property, business, goodwill, and undertaking of any association or person in the United Kingdom or elsewhere, carrying on, or in the case of a company or association formed, or empowered to carry on, any business and exercise any patent rights, privileges, licences or monopolies relating to telephones or any telephonic apparatus, or to any method, instrument or appliance employed, or to be employed, in connection with the use of electricity as a means of communication, or as a motive power or otherwise, or employed or to be employed in or for the generation, production, storing, application or distribution of electricity in any manner or for any purpose. The first subscribers are:—

	Shares.
J. Morris, 6, Old Jewry, E.C.	1
J. Brand, 65, New Broad-street, E.C.	1
F. Crisp, 6, Old Jewry, E.C.	1
J. H. Brand, 65, New Broad-street, E.C.	1
J. B. Morgan, Oxford-court, Cannon-street, E.C.	1
S. Edwards, 24, Fenchurch-street, E.C.	1
D. Parrish, 2, Copthall-buildings, E.C.	1

The Company is registered without articles of association, and consequently the regulations of Table A in the first schedule of the Companies Act, 1862, apply.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday-	Dividend.		Name.	Paid.	Price. Wednesday
3 Jan.	4%	African Direct 4%	100	102	1 Mar	5%	Gt. Northern 5% Deb., '83.	100	109
12 Feb.	1/2	Anglo-American Brush E.L.	4	3	29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17⅜
12 Feb.	2/0	— fully paid	5	4	28 Oct.	12/6	Indo-European	25	40
15 Feb.	10/0	Anglo-American	100	38¼	16 Nov.	2/6	London Platino-Brazilian...	10	5¾x
15 Feb.	20/0	— Pref.	100	64½	16 Mar.	5%	Maxim Weston	1	⅛
12 Feb., 85...	5/0	— Def.	100	13	15 May	5%	Oriental Telephone	11	7/16
28 Mar.	3/0	Brazilian Submarine.........	10	12½	14 Oct.	4/0	Reuter's	8	8¼
16 Nov.	1/0	Con Telephone & Main ...	1	¾	....	...	Swan United	3½	2½
15 Feb.	8/0	Cuba	10	13	15 Feb.	15½%	Submarine	100	150
28 July	10/0	— 10% Pref.	10	20	15 Oct.	6%	Submarine Cable Trust ...	100	97
28 Mar.	2/2½	Direct Spanish	9	4¼	29 Feb.	36/0	Telegraph Construction ...	12	39½
28 Mar.	5/0	— 10% Pref.	10	10	3 Jan.	6/0	— 6%, 1889	100	105
28 Mar.	2/0	Direct United States	20	8⅞	30 Nov.	5/0	United Telephone	5	15½
12 April	2/6	Eastern	10	11¾	....	...	West African	10	5
12 April	3/0	— 6% Pref.	10	14¾x	1 Mar.	5%	— 5% Debs.	100	92½
1 Feb.	5%	— 5%, 1899	100	110	29 Dec.........	6/0	West Coast of America ...	10	5¾
28 Oct.	4%	— 4% Deb. Stock	100	107⅛	31 Dec.	8%	— 8% Debs.	100	117
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	13⅞x	14 Oct.	3/9	Western and Brazilian......	15	10
					14 Oct.	3/9	— Preferred	7½	6⅝
1 Feb.	6%	— 6% Deb., 1891	100	106	....	...	— Deferred..................	7½	3¾
3 Jan.	5%	— 5% Deb., 1900	100	103¾	1 Feb.	6%	— 6% A	100	112
2 Nov.	5%	— — 1890	100	103	1 Feb.	6%	— 6% B	100	108
3 Jan.	5%	Eastern & S. African, 1900	100	106	....	...	West India and Panama ...	10	1
28 Mar.	8/3	German Union	10	6⅛x	30 Nov.	...	— 6% 1st Pref.	10	11
12 April	2/0	Globe Telegraph Trust......	10	6	13 May, '80...	...	— 6% 2nd Pref.	10	6½
12 April	3/0	— 6% Pref.	10	14 1-16	2 Nov.	7%	West Union of U.S..........	$1,000	125
3 Jan.	5/0	Great Northern	10	14⅝	1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Mar. ...	£39,670	+ £1,493
Brazilian Submarine	W. April 27 ...	£4,222	...	Great Northern	M. of Mar. ...	22,000	...
Cuba Submarine	M. of Mar. ...	3,800	+ £73	Submarine	None	Published.	
Direct Spanish.....................	M. of Feb. ...	1,900	+ 37	West Coast of America	M. of Mar. ...	4,175	...
— United States	None	Published.	...	Western and Brazilian	W. April 27 ...	3,524	...
Eastern..............................	M. of Mar. ...	54,376	+ 4,579	West India and Panama	F. April 15 ...	3,022	+ 649

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The estimated traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ended April 27 amounted to £4,222.

Union Electrical Power and Light Company.—An order was made by Mr. Justice Chitty, on Saturday, for the compulsory winding-up of the Union Electrical Power and Light Company.

Eastern Telegraph Company.—The Eastern Telegraph Company announce the payment, by interest warrant, of interest for the half-year ended 30th April, 1888, on their Four per Cent. Mortgage Debenture Stock.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ended April 27, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,524.

London Platino-Brazilian Company.—The Directors of the London Platino-Brazilian Telegraph Company recommend the payment of a final dividend on and after the 15th inst. of 3s. per share, free of income-tax, for the year ending March 31, making with the previous interim dividend a total of 2¾ per cent. The transfer books will be closed from the 11th to the 15th inst. inclusive.

New Firm.—Mr. V. S. Allpress, late assistant to Mr. W. H. Massey, and Mr. T. O. Be'shaw, late of the Edison-Swan Co., have joined hands and commenced business as electric light and power engineers and contractors. The firm has its offices at 3 and 4, St. Margaret's-offices, Victoria-street, S.W. Both the gentlemen comprising this firm have had considerable experience in the best class of electric lighting work.

London Platino Brazilian Company.—A special general meeting of the London Pla'ino Brazilian Telegraph Company, Limited, was held on Friday at Winchester House, Old Broad-street, to consider a proposed agreement with the Western and Brazilian Telegraph Company. Sir John Pender, who presided, moved a resolution approving the agreement, which after some discussion, objection being taken to the compensation proposed to be given to the directors for the loss of their office, was agreed to.

West Coast of America Telegraph Company.—The report of the West Coast of America Telegraph Company, Limited, shows a gross income of £57,893 for the year ended the 31st of December, against £43,026. After deducting debenture interest and all other charges, there remained a net profit of £23,115, as compared with £11,037. After adding the amount brought forward, and allowing for the £15,000 paid in dividends, the Directors recommend writing off £1,558 from the value of the repairing steamer "Retriever," thereby reducing her valuation in their books to £17,500, and to add £7,000 to the reserve fund, making the latter £27,000, leaving £334 to be carried forward.

Brazilian Submarine Telegraph Company.—The report of the Directors of the Brazillian Submarine Telegraph Company, Limited, for the half-year ended December 31, 1887, shows a revenue of £102,594, the working expenses being £12,812. After providing for debenture interest, sinking fund, and income-tax, there is, including the balance brought forward, a total of £76,916. First and second interim dividends amouning to £39,000 have been paid, and £25,000 transferred to the reserve fund, leaving £12,916 to be carried forward. In accordance with the provisions for repayment of the first issue of debentures, dated the 31st July, 1884, 139 bonds, representing £13,900, were drawn on the 26th of April for payment at par on the 31st July next. This with the previous drawing, will make a total repayment of £51,000, leaving a balane of £99,000 on the first issue of debentures.

Submarine Cables Trust.—The report of the trustees of the Submarine Cables Trust for the financial year to April 15 states that the revenue, including the balance brought forward, amounted to £18,044. They regret that the Atlantic cables competition referred to at the last annual meeting of the certificate-holders continues, and that, in consequence of the small return from their investment in Anglo-American Telegraph stock, they are unable to meet the coupons of the trust in full as they become due. The balance of £1. 10s., which was left outstanding on the coupons due on April 15, 1887, was paid on October 15 last, and the coupons which became due on October 15, 1887, were liquidated on April 16 last. The expenses of the trust and the payments on account of the coupons amounted together to £16,596, leaving £1,448 to be carried forward. This balance is equal to 8s. 6d. per cent., which the trustees propose to pay to the certificate-holders, with a further amount to be taken from the current year's revenue, as soon as they have sufficient available funds to make a substantial payment on account of the overdue April coupons.

NOTES.

Electric Lighting Bill.—The Amendment Act to the 1882 Bill was read for the second time in the House of Commons on Tuesday evening, May 8th.

Incandescent Lamps.—Incandescent lamps of 500 and 1,000 c.p. are said to be replacing the Lucigen light, hitherto used where extensive outdoor lighting is required.

Book Received.—"Principles of Dynamo-Electric Machines, and Practical Directions for Designing and Constructing Dynamos," by Carl Hering. (W. J. Johnston, New York.)

Society of Arts.—A paper on Electric Lighting for Central Stations will be read by Mr. R. E. B. Crompton at the Wednesday evening meeting of the Society of Arts. The Attorney-General will preside.

Personal Honours.—Among the personal honours with the distribution of which the Emperor Frederick of Germany has marked the opening of his reign, Dr. Werner Siemens has been ennobled and dignified with the prefix "Von" to his name.

The Largest Installation.—New Orleans, La., claims to have the largest electric light plant in the world. The power is furnished by two engines, with a capacity of 1,200 h.p. There are 1,500 arc lamps in use in that city operated by the plant.

Thermo Batteries.—A thermo-electric couple has been constructed by M. Heimel, a French electrician, which has an E.M.F. of 0·18 volt, and a resistance of 0·009 ohm. This is a great advance over anything hitherto attained in thermo-electric couples.

Melbourne.—The Australasian Electric Power, Light, and Storage Company has obtained the principal contract for lighting the forthcoming Melbourne Exhibition. It is expected that Messrs. Ganz and Co., of Buda-Pesth, will obtain the contract for the annexes.

Smoke Consuming by Electricity.—A Vienna engineer has just taken out a patent for a new smoke-abating process. By means of electricity he proposes to condense the solid part of the smoke as it rises from the coal, the carbon thus formed falling back into the furnace.

Telegraphs and Railways.—According to a statement of the Postmaster-General, there are nearly 1,600 railway stations open for telegraphic business. During hours fixed by the companies, and in cases of emergency, telegrams can be sent at other times and from other stations.

Electrical Homœopathy.—If your watch has been magnetised by a continuous-current dynamo, then—according to Mr. Lange—it may be cured by placing it within a helix in connection with an alternating-current machine—to which process *l'Electricien* applies the above term. *Similia similibus curantur.*

Waterford.—The electric light is extending in Waterford, Ireland. It is intended to lay on a new service, supplied by meter, at ½d. per hour for 8 c.p. lamp, ½d. for 16 c.p. lamps, making the cost equal to gas at 4s. per 1,000. The supply is to be on from sunset to sunrise, and to be laid on ready for next autumn.

A Trust Company.—Rumours come from Philadelphia that a syndicate with unlimited capital has been formed in New York and Boston to consolidate all the electric lighting companies in the great centres of the United States in a trust, so as entirely to control the electric lighting industry.

Electric Railroads in the States.—An electric street railroad will be built at Bristol, Tennessee, and a short electric railroad will be built by the East Land Company, of Birmingham, Alabama; and the latter city is going in for a central lighting station. The new Bristolians and Brummagemites are ahead of the old.

Telephone Extension.—The Heanor Local Board has decided to charge 5s. to the National Telephone Company, who asked permission to erect a line of telephone poles through the Heanor district, for the purpose of establishing telephonic communication between Nottingham, Sutton, Chesterfield, and Sheffield, *viâ* Alfreton.

Electric Tempering.—Electricity has been found useful in tempering watchsprings, greater accuracy as well as ease of manipulation being by its means obtainable. The spring is attached to a holder communicating to a suitable source of electricity, plunged in oil and heated to any degree of temperature while under the surface, and cooled with any degree of slowness.

Exhibition in Glogau.—At the suggestion of the Glogau (Lower Silesia) Industrial Association, in union with a large number of other industrial associations, an exhibition of small motors for hand work, industry, and agriculture will be held at Glogau from the 3rd to the 18th July. With this exhibition will be combined an exhibition of machine tools, electric lighting apparatus, &c.

Universal Electricity.—*Fire and Water* says:—"Of course, it is looking pretty far ahead to imagine a city with a system for distributing electric power, as complete as that of the present system of water works, in every street of which an engine could take power with the same readiness with which it now obtains water." Much more wonderful results than this have, however, been accomplished within the memory even of children.

Leamington.—Mr. Crowther Davies has given notice that, at the next Council meeting, he will give notice that the Town Clerk give twelve months' notice to terminate the contract for electric lighting. The Leamington lighters should look to their laurels. We believe the agitation that has been so violent against the new illuminant is destined to fail; but at the same time every effort should be made to obtain a thoroughly satisfactory and steady light.

New Electrical Governor.—An electrical governor has been patented by Mr. Frank E. Prichard, of Cedar Falls, Iowa. It is designed to control the speed of water-wheels and other motors by means of an electric current, a ratchet-wheel being connected with the valve or gate, engaging an oscillating lever carrying pawls, in connection with electro-magnetic mechanism for controlling the pawls, and a centrifugal governor for connecting the current.

Electric Alarms.—The Denison Hall Manufacturing Company, of Chicago, are introducing a neat electric alarum clock. The alarm mechanism is a small electric bell, which can be set to ring for five minutes or until stopped. The clock and the battery are enclosed in one case. It is coming greatly into use for waking railway men, and the alarm not requiring winding, recommends it for use in many cases for which persons would not trouble to wind up a spring.

New Storage Plates.—Mr. Chas. D. P. Gibson, of New York, has designed a new method of placing the active material in plates of storage batteries. The material

is placed in capsules, which are then put into holes in the plates, and the plates are then passed between rollers which compress the capsules endwise, and fasten them in the plates. The ends of the capsules are perforated to allow the air to pass out when the paste is put in, and to allow the electrolyte to enter when they are in position.

The Telegraph of the Future.—Mr. Patey, permanent secretary of the telegraph department of the Post Office, in giving evidence before the Select Committee of the House of Commons, on Tuesday, on the Revenue Department's Estimates, stated that in the course of years the department must look to a great expenditure on underground wires, not in substitution of the overground system, but in addition to it. The present cost of annual extension of telegraphs was about £100,000 a year; but the laying down of the first underground wire would cost ten times as much, and each succeeding underground wire would *per se* cost more than one overground wire.

Accumulators.—Any information about the efficiency and lasting powers of accumulators is of interest, and especially so at the present time, when a good deal of discussion has been carried on between the advocates of transformers and accumulators for lighting purposes. We notice that the Metropolitan Telephone and Telegraph Company, of New York, installed a set of 600 accumulators in the spring of 1887. These accumulators have been used to supply the current for 500 incandescent lamps, and give an efficiency of 80 per cent. Mr. Seely, the electrician in charge, is so well satisfied with the accumulators that he intends using 300 of these cells for working the telegraph instruments.

Finance.—I hear on the best authority that a few days ago one of the largest individual holders of shares in various gas companies disposed of the whole of his shares, and has re-invested the proceeds in certain electric lighting undertakings. Whether he is right or wrong remains to be seen; but judging by what has recently come under my notice, I would not care to invest much money in gas shares at present prices. Putting electricity on one side altogether, investors in gas companies should not overlook the fact that the petroleum industry is rapidly coming to the front. The race between electricity, gas, and oil will before long be an exciting one, and, if properly handled, electricity should win.—*The Lighthouse.*

Electric Light for Berlin.—According to the *Electrotechnische Zeitschrift*, the Anglo-American Brush Corporation are laying before the authorities in Berlin, through the Thüringer Bergbaugeweikshaft of Berlin, a contract for street lighting, according to which the aforesaid Company will undertake the lighting of some of the principal streets and squares of Berlin, by means of 150 Brush arc lamps, driven by four 40-light Brush machines. They will be arranged in four circuits, the cables to be laid underground in Callender's bitumen. Part of the lamps are to run all night, the remainder till midnight. The town pays a rental of 30 pfennig (3½d.) per lamp-hour, which, at 396,837 lamp-hours, gives a cost of 119,051 marks (about £5,800). The town pays for its own lamp-posts.

School of Electrical Engineering.—A very satisfactory report has just been received by the managers from the external examiner, H. R. Kempe, Esq., of the G.P.O., showing that out of 14 students of the advanced class who went in for the final examination held on April 18, in which 70 per cent. of the marks is required, 8 obtained the vellum certificate with the following percentages:—H. F. S. Crawford, 94·6; A. H. French, 88·6; T. W. Watts, 88; A. O. Jensen, 87·3; H. A. McCausland, 86; E. L. Simpson, 85·3; E. H. Greg, 80·6; A. E. Beddoe, 71·3. About two months ago, as the result of an examination in engineering, the following students also obtained the vellum certificate:—L. M. Green, 97·3; H. E. Taylor, 97·3; P. T. Heath, 90·6; H. A. Irvine, 88·6; R. Cotton, 87·3.

Value of v.—The ratio v between the absolute electromagnetic and electrostatic units of quantity has been recently determined by M. Himstedt by means of Maxwell's condenser method. The mean value obtained in fourteen experiments, giving very concordant results, was—

$$v = 3{\cdot}0074 \times 10^{10} \text{ centims. per sec.}$$

This value is lower than that obtained by Weber and Kohlrausch ($3{\cdot}1074 \times 10^{10}$), but higher than those obtained by Sir W. Thomson ($2{\cdot}825 \times 10^{10}$), Clerk-Maxwell ($2{\cdot}88 \times 10^{10}$), Ayrton and Perry ($2{\cdot}98 \times 10^{10}$), and Gordon ($2{\cdot}9857 \times 10^{10}$). It approximates closely to that obtained by Cornu—viz.: ($3{\cdot}004 \times 10^{10}$). All these determinations differ but little from the velocity of light in vacuo, which, according to Foucault's determination, is 2.98×10^{10}.

New Electric Motor for Tramcars.—A motor of novel design has been made by the "Helios" Electrical Company, of Ehrenfeld and Cologne, to overcome the difficulty experienced in starting cars. The motor has field-magnets connected with the wheels of the car; the armature revolves loosely on the same shaft, but its revolution can be checked by a brake, when the field-magnets begin to revolve, driving the car. The driving-wheels have also a brake, which is connected with that previously mentioned, so that by taking the brake off the armature the brake on the driving-wheel is put on, and *vice versa*. The motor is started at full speed, allowing the armature to revolve; as its motion is gradually stopped by the brake, the motion of the brake handle releases that of the driving-wheels, which gradually revolve faster as the armature stops.

Technical Education in India.—Mr. Alfred Chatterton, B.Sc., has been appointed professor of engineering to the college at Madras. The selection was entrusted to a committee appointed by the Secretary of State for India, consisting of Sir Alexander Taylor, Prof. Unwin, and Sir Philip Magnus, who recommended two gentlemen, and of these Mr. Chatterton has been chosen. Mr. Chatterton was educated at St. Mary's College, Peckham, and subsequently studied at Finsbury Technical College, where he gained the Clothworkers' exhibition and numerous medals, and has since taken his London degree. Mr. Chatterton has gained his practical knowledge at the locomotive works of the London and South-Western Railway Company at Nine Elms, where he has also been engaged in teaching the evening classes for apprentices. The Finsbury men are beginning to be appreciated.

The Writing Telegraph.—The promoters of the latest system of writing telegraphs are largely endowed with Yankee persistency, and members of Parliament, of course actuated by the purest designs, somehow or other generally seem willing to assist the promoters. It is quite clear that having purchased the telegraphs, the Government cannot, from a business point of view, allow unlimited competition. The telephonic competition will have to be bought up, and one such purchase is enough even for England during each decade. The Postmaster-General, replying to Mr. M'Ewan, said if there is a substantial demand for the establishment of exchanges to be worked by the instruments of the Writing Telegraph Company, it would be preferable that

they should be in the hands of the Post Office, the instruments being supplied by the proprietors on terms to be arranged. We do not for one moment anticipate that any such demand is possible. A writing telegraph is not wanted for ordinary work, and the exceptional work is far too scarce to justify any expenditure in fitting up the system.

Brussels.—A prize of £10 is offered by the Belgian Society of Electricians for the best elementary essay on the principles of electricity, for use by persons of ordinary education engaged in electrical pursuits. Simplicity and clearness are the essential qualities; algebraic formulæ are only admitted in appendices. Demonstration of the laws need not be attempted as a rule. Magnetism need be treated only so far as necessary for comprehension of electro-magnetism. The offer is open to the world, but the essay must be written in French. The author preserves his copyright, but it is to be first published in the Bulletin of the Société. Manuscripts must be written on one side of the paper only, and must bear a motto or *nom-de-plume*, accompanied with a sealed letter bearing name and address of author, and must be addressed, before January 1st, 1889, to M. Bede, President de la Société Belge d'Electriciens, 37, rue Phillippe le Bon, Brussells. Further particulars can be obtained of M. E. Lagrange, Secretaire de la Société, 26, rue Vilain XIII., Brussells.

Electric Fire Alarm.—A very simple apparatus for indicating a rise of temperature in any portion of a building has been devised by M. Piau. The essential part is a glass globe, the neck of which is closed by a membrane which, by the expansion of the contained air, is made to close the circuit of a battery and bell. The apparatus is regulated by means of a screw, carrying one of the platinum points brought into contact by the inflation of the membrane; the other platinum point being attached to a spring in close proximity to the membrane. In order to render the instrument independent of barometric and ordinary temperature variations, it has been found advisable to establish a communication, by means of a minute orifice, between the enclosed air and the surrounding atmosphere. By means of this device only sudden variations of pressure, such as would be due to a current of heated air arising from combustion, are indicated. The apparatus should be placed at a considerable altitude above the floor; and we think that the objection of fragility might require to be obviated by the use of a globe or other vessel of copper, in lieu of one of glass.

Miner's Lamps.—At a meeting of the members of the North Staffordshire Mining Institute at Stoke-on-Trent last week, Mr. J. W. Swan read a paper on the "Edison-Swan's Electric Miners' Safety Lamp," which was described and illustrated in our issue of January 20. Numerous questions were put to Mr. Swan on the subject, and it was explained that the principal points aimed at in the lamp were safety and abundance of light, the size of the lamp not necessarily being a fixed one. An arrangement had been designed, and could be applied to a portion of the lamps, to indicate the presence of gas, and another arrangement, which might be used in conjunction with the electric lamp or independently, was shown for testing the percentage of gas in a mine.—At the Astley Institute, Dukinfield, Mr. Oswald R. Swete, electrician to the New Portable Electric Lamp and Power Syndicate, read a paper on "Lighting Mines by Electricity." Mr. A. C. Boyd, J.P., occupied the chair, and after the reading of the paper, which dealt in a popular manner with the history of the lighting of mines, the construction and working of the portable lamp put forward by the syndicate, and the advantages of flameless illumination in the case more particularly of mines, questions were asked by several of the miners present, and were answered by Mr. Swete. The meeting concluded with a vote of thanks to Mr. Swete and to Mr. Nicholson, one of the directors of the syndicate.

Wire-covering Machinery.—The price-list of Messrs. Thomas Barraclough and Co., Manchester, contains a very comprehensive list of improved and new machinery for covering, stranding, and sheathing electric wires and cables. Types A to D are yarn-winding machines; E to J, vertical and horizontal machines for covering electric wires with silk, cotton, jute, &c., for sizes 5 to 32 B.W.G., and with tanks for compound if necessary; K and K_1 are for very fine wires, constructed to run at the highest speed the material will stand. The braiding machines are made in two patterns—for floor or for bench, and present two important advantages—(*a*) they can be run at a high speed; (*b*) they are furnished with large carriers, so as to run a considerable time before stopping to replace the bobbins. Several lately patented inventions are introduced; for instance, all the machines, except the smaller sizes, are furnished with adjustable feed or draw-through apparatus, so as to regulate, by means of gearing, with the greatest nicety, the speed at which the braided wire is drawn out, thus causing the covering material to be applied to the wire with the exact degree of density required. They are also constructed with a weight to each carrier, so that in case of a strand breaking, the machine stops automatically, preventing imperfect work. Taping, tarring, wire-winding, and cabling machines are also included, and machines for sheathing shore ends of cables.

Accumulators for Tramways.—Before the *Société Electrotechnique* of Vienna, Baron Roman Gostkowski discussed the advantage of the employment of accumulators for tramways, and pointed out the reasons which should lead to the substitution of other motive forces to that of traction of horses. For increase of profits it is necessary either to increase the receipts or reduce the cost. The first can be obtained by increasing the speed of travel, the second by use of cheaper motive power. If the speed is to be increased, the resistance to traction must be diminished, or greater power employed. The speaker gave some interesting information upon the best relation of tare to net weight in vehicles, and pointed out that the best result was obtained when they were as 1 to 1. With regard to augmentation of force, he showed it was impossible to expect this from horses, they already being worked beyond normal power. It is, therefore, necessary to employ other motors. In comparing steam engines (which are too heavy), compressed air (which take too much room), and other motors, he came to the conclusion that the best form was an electric motor, fed with accumulators. He showed by calculation, and by the result of experiments made with accumulators, that in using this power a much greater speed can be obtained than with horses, the cost being about the same. He ended by expressing the view that this mode of traction would soon be adopted in Vienna.

Trouve Motors for Pleasure Boats.—The *Revue Internationale* gives an abstract of a paper by M. Trouvé read before the Association Française pour L'Avancement des Sciences, at Toulouse, in which he describes various apparatus he has perfected for the application of small electric motors to pleasure boats, which he thinks will be

adopted on a large scale. The inventions consist of a light and powerful motor, a new method of construction of the propeller, a commutator for forward, backward, or change of motion, signal of alarm, or electric siren, as well as a powerful signal light for avoiding collisions. The inventor points out that it is well known that a steam boat will not easily run a clear distance of 3,000 miles, whereas with electricity, even in its present development (while the steam engine is at its greatest development), double the distance is easily run. M. Trouvé, before terminating, called particular attention to his latest inventions :—(1) A very small electric motor, extremely light (0·2lb.), which, furnished with an air-screw, and set in motion by a current, could raise itself into the air ; (2) an interrupter, for currents of high tension, to suppress sparking; (3) an electric Auxanoscope, for projecting the images of opaque bodies under conditions of extreme simplicity. M. Trouvé projected the portraits of MM. Chevreul and Pasteur. Those most successful were of pieces of money, and, above all, of a watch in motion. M. Trouvé also showed many applications of the electric light to the work of naturalists, chemists, and microscopists.

Simple Arc Regulator.—The *Comptes-rendus* has received a description of a new and simple regulator for arc lamps, designed by M. Charles Pollak, depending for its action upon the lengthening of a wire under the heating action of the electric current. The current is led to each carbon by a brass wire sufficiently thin (0·45millims.) to be sensibly heated by the current, and kept tightly stretched by a spring. This spring, also of brass wire, is twisted in the form of a helix, and so disposed as to form at the same time a tension spring, a multiplying lever arm, and the carbon holder. The second carbon is fixed in like manner, the apparatus being symmetrical. The carbons, at first, are in contact until the circuit is closed, when the straight wires stretch and the carbons separate. The rc being formed, the resistance it introduces limits the heating of the straight wires, and therefore the length of the arc remains constant. As the carbons burn away, the increase of resistance which results causes a decrease in the lengthening by the heat, and therefore a corresponding adjustment of the carbons. The apparatus thus constructed regulates the electric arc for a period of three hours. It relights automatically ; its action is regular and satisfactory. It is necessary to add, however, that by its construction, the strength of current, and therefore of luminosity, gradually increases somewhat during action. Such a regulator will be serviceable by reason of its extreme simplicity, no mechanism nor electro-magnets being necessary. All that is required to make it is a piece of board and four pieces of brass wire. This lamp seems to indicate a new departure in regulation, but it is doubtful whether the lamp described has much practical value.

Improved Electrical Speed Indicator.—A simple device by which the increase or diminution of speed in machinery above or below its normal rate may be indicated electrically has been patented by Mr. Frederick W. Schlepegrell, of 20, Ashton-street, Charleston, South Carolina. The indicator shaft, arranged to receive motion conveniently from the machine whose speed is to be indicated, is formed of two parts connected together by an insulating sleeve, and is journaled in a frame whose upper and lower parts are connected by a threaded insulating sleeve, binding posts, connected with an electric-bell or alarm, being secured to the lower and upper parts of the frame. In grooves on opposite sides of the indicator shaft are secured flat springs, with a weight, preferably of spherical form, on the outer extremity of each spring, a nut being fitted to move up or down on the shaft to vary the length of the free ends of the spring arms. The weights are adjusted relative to the motion of the indicator shaft when driven by a machine, so that when the machine runs at its normal speed the weights will revolve in a position between the upper part of the shaft and the contact screws on either side. When the speed of the machine increases, so that the weights touch the contact screws, the circuit is completed and an alarm is given, a like effect being also produced when the machine runs slower than its normal speed, or when it stops, as the weights are then brought into contact with the upper part of the indicator shaft, thus completing the circuit. The indicator may be adjusted to adapt it to higher or lower speeds by turning the nut on the lower portion of the indicator shaft, thus shortening or lengthening the spring arms, and also by turning the contact screws in or out.

Scientific Industries.—Lord Thurlow, F.R.S., presided on Tuesday night at a house dinner of the City Liberal Club, Walbrook. *The Times* reports among those present Dr. Silvanus P. Thompson, Mr. David Chadwick, Mr. J. W. Swan, Sir Douglas Galton, K.C.B., F.R.S.; Admiral Bythesea, C.B., V.C. ; the Rev. William Windle, Mr. E. Rider Cook, Mr. J. I. Courtenay, Mr. A. H. Renshaw, Mr. William Westgarth, Sir J. H. Johnson, Mr. John Pound, Sir John Bennett, and Mr. T. W. Deverell (the secretary). The speeches made related entirely to science as applied to industrial purposes. After the reception of the usual loyal and patriotic toasts, the Chairman proposed the toast of the evening, "Scientific Industries." It seemed to him, he said, that there was no place within Her Majesty's dominions where such a subject should find such ready acceptance as in the heart of London, when they considered what London was to-day, and the extraordinary conditions in which our daily life was continued. Referring to the electric light, one of the scientific industries with which he was personally acquainted, he expressed his conviction that it would infallibly, sooner or later, take its place as the universal lighting agency of this great city. He concluded by coupling with the toast the names of Mr. Swan and Dr. Silvanus Thompson. Mr. Swan reminded them that as an established industry the electric light was barely eight years old. In England it had two great difficulties to contend against—very good and cheap gas and the Act of 1882. Thanks to the persistence of Lord Thurlow, the obnoxious features of the Act appeared as if they were about to be swept away ; and with regard to cheap gas they must fight it as best they could. The electric light had advantages over gas in purity and safety ; and on the score of cheapness alone it could in some cases beat gas. He had every hope that before long the electric light would be brought within the reach of every one by the establishment of stations. Dr. Silvanus Thompson said he could not help thinking that, so soon as the Electric Lighting Act was amended, there would be a very great development of arc lighting. Though not behind the United States and the rest of Europe in regard to electric lighting, we are very far behind the United States in the development of the electric telephone. He proceeded to show that in other branches of science great progress had been made of recent years. When we had overhead railways, we should not be content to have the trains driven by means of ropes. Mr. David Chadwick

proposed the toast of "Railways and Commerce," to which Sir Douglas Galton replied.

Motor for Submarine Boat.—The *Revue Internationale* gives the result of some trials of a motor fed by accumulators for a submarine boat, commissioned by the Ministre de la Marine of France, now nearly completed. The tests were carried out on land. The principal motor, which is to actuate a screw of 5ft. diameter, has sixteen poles, disposed symmetrically round a movable ring, 3ft. diameter. It is furnished with four brushes, two for forward and two for backward running. The motor is to furnish 52 h.p., calculated at a normal current of 200 amperes, at 192 volts. The source of electricity is a battery of 564 accumulators, each weighing 38lb., with alkaline solution, constructed by Messrs. Commelin, Desmazures, et Baillehache. These are grouped in four different ways, so as to obtain, by means of a special switch, four different speeds by movement of a handle. The first group, slowest speed, consists of twelve groups of 47; the second, medium speed, six groups of 94; the third, ordinary speed, four groups of 141; the fourth, quickest speed, two groups of 282. The Commission appointed by the Minister went, on March 16 last, to Havre, to the works of the Société des Forges et Chantiers, who have built the machine. The motor being fixed, the screw was replaced with a water turbine to oppose an equal resistance to that of the screw. The accumulators had been charged, grouped in the third manner, with a current of 100 amperes, with a difference of pressure of 140 volts at the terminals. The length of charge was 23 hours; the pressure varied from 135 at the beginning to 144 volts at the end. The charging was prolonged beyond the time necessary, because many of the accumulators were charged for the first time. The total capacity of each accumulator resulting from the weight of zinc contained in it, is 520 ampere-hours. The quantity of electricity supplied in the charging current was 575 ampere-hours. The discharge was arranged with the fourth grouping, quickest speed. It lasted four hours and a half, giving 58 h.p. for the first three hours (206 amperes and 200 volts); 54 h.p. for the fourth hour (200 amperes and 200 volts). At the end of four and a half hours the power fell to 47 h.p. (190 amperes and 183 volts), but a part ($\frac{1}{20}$) of the accumulators discharged themselves by reason of insufficient insulation. In spite of these unfavourable conditions, the discharge of $4\frac{1}{2}$ hours had utilised $450/520 = 0{\cdot}863$ of the total capacity of the accumulators. Taking into account the difference of potential between charge and discharge as 1 to 0·75, the return of energy was $0{\cdot}863 \times 0{\cdot}75 = 0{\cdot}65$ of energy produced. Under these conditions the weight of accumulators, case, and liquid is 81lb. per h.p. returned. The next day, without recharge, the accumulators gave several hours' work, at different speeds, for testing the change of speed of the motor. The resistance of the motor is 0·16 ohm, greatest speed 280 revolutions per minute, with a current of 200 to 210 amperes. The field-magnets (mean field 3,000 C.G.S. units) attained a temperature of 40deg. centigrade, after $4\frac{1}{2}$ hours running at greatest speed.

Royal Society Soiree.—The first annual soirée of the season was held on Wednesday evening at the rooms of the Royal Society, Burlington House, when the fellows and guests were received by the President, Prof. Stokes, M.P. The Royal Society holds two annual soirées, one in May and the second in June. From a scientific point of view the former is by far the more important of the two. At it the leading workers in science produce, for public inspection, what we may call the *pièces justificatives* of the new discoveries and new theories which have been brought forward during the year. Among the most interesting exhibits were those of Mr. Norman Lockyer, to illustrate his theories relating to meteoric streams. Mr. Eric Stuart Bruce exhibited his electrical translucent balloon for flashing signals at night. The utility of such an arrangement in naval and military operations is obvious, and to judge from the experiments last night, Mr. Bruce's balloon ought to be efficient. The apparatus consists of a captive balloon made of perfectly translucent material, having several incandescent electric lamps ingeniously supported inside, a metallic circuit connecting the lamps with a source of electrical power on the ground. Mr. Shelford Bidwell showed his apparatus for measuring the changes produced by magnetisation in the dimensions of rods and rings of iron, cobalt, nickel, bismuth, and other metals, and this instrument is so delicate that it will measure changes of length to the 25,000,000th of an inch. The effects of magnetisation in the contraction and expansion of the rods, as shown by the apparatus, are very curious. Two sets of miners' electric safety lamps were shown in the library. One of them, exhibited by the Edison and Swan Company, is only 7in. by $4\frac{1}{2}$in., and weighs about 7lb. The Schanschieff Electric Light and Power Company showed another lamp in various forms according to power and duration of light; and these seemed to be really of practical utility and as safe as could be expected. One of the most delicate pieces of apparatus shown was Mr. C. V. Boys's radiomicrometer, probably the most delicate instrument for measuring heat yet made. It consists of a circuit made of antimony, bismuth and copper hung in a magnetic field by a fibre of quartz so fine, that if magnified to 20 times its size, it would still be finer than spun glass. Since last year Mr. Boys has introduced improvements which render the apparatus almost perfect. Equally delicate were Mr. Boys's experiments with soap bubbles. A good deal can be done to soap bubbles without injuring them. At the same time an extremely slight electric influence brought near a pair of bubbles made them run into each other. In the same room where these were shown the Meteorological Society had a fine exhibit, consisting of a series of many photographs of flashes of lightning, which were highly instructive when compared with a neighbouring exhibit of three diagrams of lightning made by James Nasmyth in 1858, showing (1) Nature's lightning; (2) painter's lightning; (3) forked lightning. One exhibit, not only of great beauty, but having important practical bearings with reference to the present inquiry as to the decay of water-colours, was the elaborate apparatus of Captain Abney and General Festing for measuring the light reflected from coloured pigments. The powerful electrical influence machine of Mr. James Wimshurst was also exhibited, which, with Leyden jars, gives a spark $13\frac{1}{2}$in. long. A somewhat similar machine was used by Dr. Marcet in the meeting room for illustrating on the screen flashes of lightning of various kinds. Robertson's writing telegraph naturally excited great astonishment, not only by its admirable performances, but by the simplicity with which it is worked; though some seemed to think it would add one more terror to life. The holophotometer exhibited by Woodhouse, Rawson and Co. is a marvellous apparatus, of great ingenuity, for measuring, by a careful adjustment of mirrors, the intensity of light all round. The rooms were brilliantly lit up by the electric light.

DOUBLE AND SINGLE EARTH WIRE SYSTEMS FOR ELECTRIC LIGHTING.

BY J. D. F. ANDREWS.

During the seven or eight years that the illumination of buildings has been possible by means of the glow lamp, the development of the system of wiring has made exceedingly slow progress towards that state of simplicity and universal sameness that gas now holds. We can attribute this backwardness to many causes. The difficulty of having to deal with two conductors instead of only one is greatly in the way, and the influence of some insurance companies, who insist upon a compliance with certain rules, may have had a retarding effect, but most conspicuous amongst the influences is the fact of many contractors taking advantage of a flimsy nature of construction that electric light fittings and appurtenances are so easily adapted to, with a view to reduction of cost, regardless of durability and system.

One of the objects of the following article is to explain the results of some experience in the system now generally known as the single wire system, which would be more correctly called the earth system. The earth system has now been applied to a large number of installations, mainly at sea, but also to some on land. The main points of difference with the double wire systems are shown diagrammatically in Figs. 1 and 2. The current, Fig. 1 (which represents the double wire system), is supposed to leave the dynamo by the black wire, pass through the fuses, F, to the lamp, back by the red wire (shown dotted), through the fuses to the dynamo. It is essential in the double wire system that there should be fuses on both wires, so as to prevent as far as possible the danger from a short circuit, which can be brought

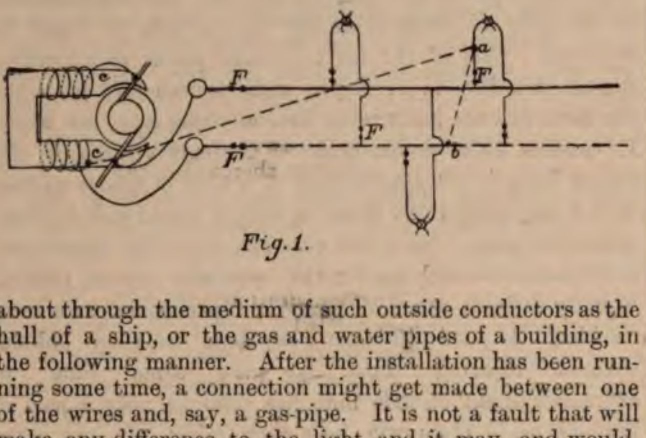


Fig. 1.

about through the medium of such outside conductors as the hull of a ship, or the gas and water pipes of a building, in the following manner. After the installation has been running some time, a connection might get made between one of the wires and, say, a gas-pipe. It is not a fault that will make any difference to the light, and it may, and would, most likely, not be discovered until something else happens. Supposing the connection above referred to, to be at A, Fig. 1, and that later on another connection is made at B, on the opposite wire, it is evident that now the iron pipe short-circuits the two wires, and if there were not fuses on both wires, the single light wire, A, would doubtless get very hot before the main fuse melted. But the fault might be worse still. Supposing fuses only to be on the lead, none on the dotted wire, the second earth-connection might be in the dynamo at C; in this case all the fuses would be beyond the short-circuit, and the consequence very serious. Of course, with fuses on both wires, as shown in the figure, such accidents are provided against.

It is, however, possible to provide against such accidents without double pole fuses, and thus greatly reduce the danger of fire from this source. This alternative is to connect one of the wires to earth on a main water or gas pipe, as shown in Fig. 2, which illustrates the earth system. It is obvious that fuses would be unnecessary on the earth or return wire, and with fuses properly distributed and adjusted over the leading wire no short-circuit could exist; and if an earth connection took place in the dynamo, the danger would be confined to the machine.

It might be said that the insulation of the machine is more liable to break down through the earth connection. This, however, has not been found to be the case in practice, and the explanation is that while there is full pressure between the body of the machine and the wire at one terminal, there is no pressure at the other. Whereas when the body of the dynamo is insulated from both terminals, the pressure between the body and either terminal is half the total pressure, but the whole dynamo is exposed to this pressure. The strength of this argument lies in the fact that the quantity of electricity in electric lighting is out of all proportion to the pressure.

For reasons very similar to the above, it is not necessary to increase the insulation of the leading wires, but there are also other points to consider. In the double system two faults can happen—a connection to earth, and a direct short circuit to the opposite wire; the pressure to earth from either mains being half the total, if both wires are equally insulated. In the earth system there is only one fault that can happen, namely, the connection of the lead to the earth wire or earth; and although there is the total pressure between the wire and earth, there is only half the length of wire. At all points where the insulation of the wire is critically exposed, the conditions with the earth system are much more favourable for preserving it. For instance, in the fittings the leading wire has the whole space at its disposal; that in the double system would be for two wires in passing down the centre of the tube. Usually with the earth system this central wire is heavier insulated, and is much larger in section than is required for the current, so as to be rigid within the fitting, to prevent continued vibration and contracting and expanding, destroying the insulation, as has often occurred in both systems; and by using a wire of large practical size the parts of the fittings can be wired separately and screwed together with butt contacts. The fittings are, of course, all connected to the earth return wire. In the event of a building lighted electrically being struck by lightning, an

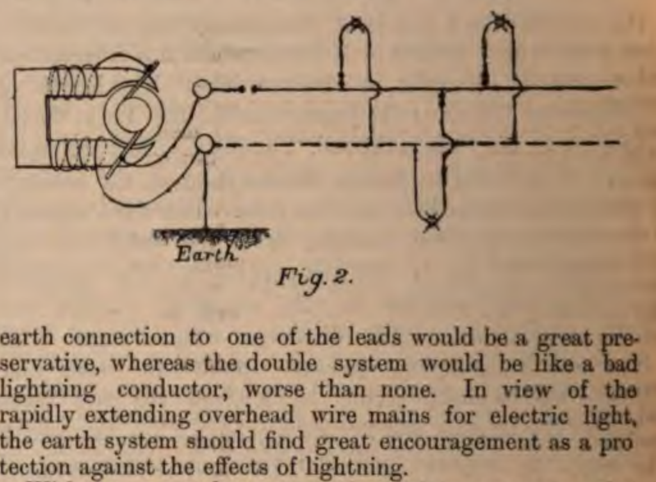


Fig. 2.

earth connection to one of the leads would be a great preservative, whereas the double system would be like a bad lightning conductor, worse than none. In view of the rapidly extending overhead wire mains for electric light, the earth system should find great encouragement as a protection against the effects of lightning.

With the reserve due to want of experience we may say that also with transformers the earth system is a safe protection from lightning, even supposing the primary circuit to be double wired to guard against induction in other wires. The transformers can be protected by a lightning protector, or it may be the lightning protector itself. The protection would be definite and known, whereas the only lightning protection under the present arrangement is the dynamo producing the current, which has already, on some occasions, been known to play its part in this function. Although induction in telephone wires is a reason that might prevent an earth connection being adopted with transformers in both primary and secondary circuits, yet the many advantages of the earth connection may bring about its adoption notwithstanding. In the event of concentric wires, such as previously described, being employed, and these buried in the earth, it will doubtless be necessary to connect the outer sheathing to earth plates at intervals to prevent electrolytic action between one section and another destroying the sheathing. The action would be transferred to the earth plates, which might consequently require to be renewed at long intervals. Of course other means could be employed to preserve the sheathing or outer conductor, although none would have the special advantage of reducing the resistance of the return circuit that the earth plates introduce.

Another point where the insulation of wires is exposed is at the fuses. In the double wire system the fuses of each wire, to be practical, must be near each other, and conse-

the opposite sides of the circuit are exposed in close ty. In the earth system, however, only the lead ter the fuse box, and there is consequently no such re.

reference to the fuses themselves, there are sub- reasons why it is advantageous to reduce their as is effected by the earth system. It is well known arc from metal joints can be stretched to a consider- ngth—two or three inches with 100 volts under circumstances—and the arc often continues an able time after the fuse has melted. If a fuse is cted of lead or copper wire, it is often red hot long t melts.

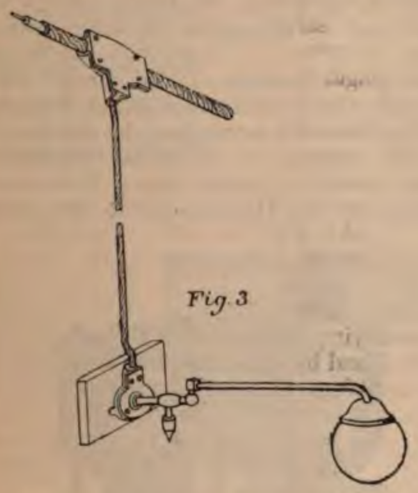


Fig. 3

chief danger of producing fire through electric light not a dead short circuit, but a partial short circuit, opening circuit. A partial short circuit is an arc the two wires or some other cross connection that t increase the current sufficiently to melt the fuses, re therefore a provision for safety, but may or may Against opening circuits, through corroding wires getting stretched and broken, there is no protection rdinary system of wiring; this fault is therefore the ngerous, and not the least frequent. The single- stem stands to advantage in this respect, on board ecially, there being only about half the length of such faults to appear in.

curious instances have come under the writer's f opening circuit faults. One case, in a ship, water ged in a groove with one of the wires, which was d with pure rubber, cotton serving and braided. ater penetrated this insulation, and the electric passed through the water to a more distant part of e wire, carrying with it electrolytically some of the of the wire, depositing it on the outside of the insu- t three or four yards distant. In another instance ing circuit on board ship smoke was observed to be from an electric light wire casing, and on removing

Fig. 4.

a dull red glow about 6in. long was observed in the occupied by one of the wires. The wire had appa- got broken, and an arc formed, which gradually the ends wider apart, and the current found passage the charred wood.

ough it is impossible to entirely prevent opening their danger can be minimised by causing them to a short circuit, and thus come under the protection uses or cut-outs. This means running the wires so gether that any heat in one would act upon the nd produce a short circuit. Such is the theory, but practical carrying out of such an arrangement, n must be made against the possibility of only a partial short circuit. The different points of this case are well met in a system of sheathed wiring designed by the writer some years ago, and now in extensive use on shipboard. The illustrations (Figs. 3 and 4) shows the system as now constructed by Messrs. Muir, Mason, and Coulson, Glasgow; it is essentially earth wiring, the leading wire, which is insulated with vulcanised rubber, being surrounded with a sheathing of iron wires which form the return. An open or opening circuit is an almost unheard of thing with this wiring, but should it take place a short circuit and the melting of a fuse are the immediate result. A partial short circuit is also a circumstance almost inconceivable with such a system. And notwithstanding that every fault results in a short circuit, experience has proven that short circuits are less numerous than with the ordinary wiring, which is attributable to the great protection of the sheathing. The switches and fuses are arranged in cast-iron boxes resembling the joint boxes, and are placed invariably together, and only at the junction of a sub-main with a main. Usually a sub-main is arranged to supply only 12 lamps 100 volts, in which case the smallest branch wire is No. 15 S.W.G.; it being calculated that this size will carry without danger of fire the current that will melt the fuse. If the sub-mains, and consequently one switch and fuse, have to carry more than eight amperes, the smallest wire must be chosen larger in correspondence to the current. For 30 100-volt lamps the smallest wire is No. 12 S.W.G.

THE LATE SIR CHARLES T. BRIGHT.

We regret to announce the death of Sir Charles Bright, immediate Past-President of the Society of Telegraph-Engineers, who may be considered as one of the founders of the first Atlantic telegraph, in connection with which enterprise his name is chiefly familiar to the public, and who is known also as having been engaged in the development of telegraphic communication from its early stages up to the present time. We cannot do better than follow the *Times* in its notice, although, perhaps, the completest record of the late Sir Charles Bright's work will be found in a biographical notice which appeared in our own columns in the issue of July, 1883. Charles Tilston Bright was born in 1832, the youngest son of the late Mr. Brailsford Bright, the head of an old Yorkshire family long settled in Hallamshire. Charles Bright was educated at the Merchant Taylors' School, and from his schoolboy days he turned his attention to electricity and chemistry. He was, from the age of fifteen, engaged with the Electric Telegraph Company, and worked for some years under Sir William Fothergill Cooke in introducing and developing telegraphs for the public service. Among his services in this regard, it may be mentioned that he was occupied in the establishment of telegraph stations on several lines in the North of England and in Scotland. On one occasion—this was before he came to the age of 21—he was called upon to lay underground wires in Manchester. It was essential that the traffic of so busy a city should be interrupted as little as possible. Charles Bright did not interrupt the traffic at all. In one night he had the streets up, laid the wires, and had the pavement down before the inhabitants were out of their beds in the morning. In 1852, at an age when many professional men have hardly begun their life's work, he was appointed engineer-in-chief to the Board of the Magnetic Telegraph Company, in whose service his elder brother Edward had been acting as manager for some years. The two brothers worked together and patented a series of inventions in connection with telegraphic apparatus. Among these inventions were the system of testing insulated conductors to localise faults; various inventions relating to coils; the employment of a movable coil on an axis actuated by a fixed coil; the double roof shackle, the vacuum lightning protector; the translator or repeater for re-laying and re-transmitting electric currents in both directions on a single wire; the employment of a metallic riband for the protection of the insulated conductors of submarine or underground cables; the production of a varying contact with mercury proportionate to the pressure exerted upon it; a new type-

printing instrument; and a method of laying underground wires in troughs. Several other telegraphic improvements were carried out by him in the course of his life. While he was working out these inventions, he was also engaged in practical work in laying down lines in many parts of the United Kingdom, and he was the engineer who laid down the first cable which united Great Britain with Ireland. This was in 1853, and there is reason to believe that while he was prolonging the lines through Ireland he was already planning the continuation of the wire across the Atlantic. He had been experimenting for some time on the system of insulating wires in gutta percha tubes; and his experiments on a wire 2,600 miles long led him and others to the conviction that telegraphic communication with America was easy. The capital necessary for the purpose was raised, and in 1858, as engineer-in-chief, he successfully laid the first Atlantic cable of over 2,000 miles in length, and the work was completed in August, 1858, after eight days of work, during which the four ships engaged, which were lent by the British and United States Governments, had to bear the brunt of a violent storm in the middle of the Atlantic. After this signal service Mr. Bright was knighted by the Lord-Lieutenant of Ireland. After carrying out a few operations in submarine telegraphs in the Mediterranean and in the Baltic, he was summoned, in 1864, by the Government of India to complete the communication with Europe, which work he personally superintended and accomplished by joining Kurrachee with the northern end of the Persian Gulf. Within the next few years he superintended the laying of cables between the United States and Cuba, and united various parts of North and South America, the West Indies, and other places. In a paper read by him at the Institution of Civil Engineers in 1865, he advocated submarine telegraphs to China and Australia, and this paper, together, no doubt, with the excellence of his previous services, gained him the Telford gold medal of the institution. He was elected member of Parliament for Greenwich in 1865, and continued to represent that place for several years in the Liberal interest. In 1881 he was appointed by the Foreign Office as Commissioner, with the Earl of Crawford and others, to represent this country at the French International Exhibition, and he was in consequence nominated by the French Government an officer of the Legion of Honour. Last year, at the meeting of the Society of Telegraph-Engineers and Electricians, Sir Charles Bright delivered the inaugural address, in which he dealt exhaustively with the whole subject and history of the telegraph during the past 30 years. He married, in 1853, Hannah, daughter of the late Mr. John Taylor, of Kingston-upon-Hull. Sir Charles Bright died on Thursday, May 3, at the residence of Mr. Edward Bright, at Abbey Wood, in Kent. The funeral took place on Monday, the first part of the service being held at St. Cuthbert's Church (opposite Sir Charles' residence), at 11 o'clock in the forenoon. A large number of friends gathered together at St. Cuthbert's, many of whom followed the remains of their late friend to Chiswick. Among those able to pay this last tribute of esteem and respect we may mention: Prince Victor Hohenlohe Schillinghurst, Sir Robert Jardine, Sir David Salomons, Sir Frederick Goldsmid, Prof. Sir William Thomson, Sir Samuel Canning, Mr. E. Graves, president of the Society of Telegraph-Engineers; Mr. Latimer Clark, Prof. Hughes, F.R.S., and Mr. W. H. Preece, F.R S., past-presidents of the society; Mr. Benest, Mr. R. Collett, Mr. Clifford, Mr. H. C. Forde, Mr. R. K. Gray, Mr. John Muirhead, Mr. E. Stallibrass, Mr. E. March Webb, Mr. F. C. Webb, Mr. F. H. Webb, and Mr. J. Stoddart. This brief notice may well end with the concluding paragraph of the biography previously referred to: "There are some men whose talents impress us more than any other of their merits, and stand out gaunt and bare like some projecting cliff, with nothing gentle to relieve the eye or mask the height. There are others in whom a keen intellect is sometimes veiled by geniality of manner, just as a rocky hillside may be overhung with verdure. It is to this category that Sir Charles Bright belonged, and though his past services may well command our admiration, the better part of our praise is, that those who have had the pleasure of his acquaintance, love rather to remember the kind and sociable qualities of the man than the succes the engineer."

THE ITALIAN EXHIBITION.

Solomon, if he were alive now, would, no doubt, "Of the making of exhibitions there is no end," for seem to abound on every hand. The Italian Exhi (Macaronaries) occupies the position this year th Yankeries held last year, but with this difference whereas the American show depended for its attra principally upon the "Wild West," the Italian Exhi will really contain a finer display so far as exhibit concerned, and will depend less upon adventitious ai attraction.

It might almost be assumed that the advent of el lighting made these exhibitions possible; at any rate system of lighting is a necessity under the conditions obtain. The lighting of the Italian Exhibition is carried out entirely by Messrs. Laing, Wharton, and I who use the Thomson-Houston system throughout. I

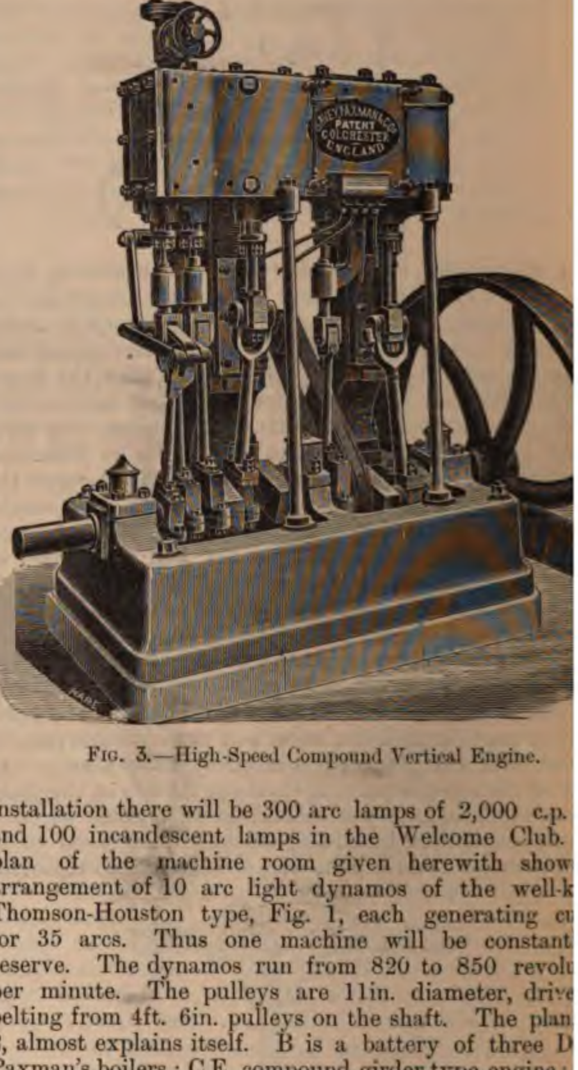


FIG. 3.—High-Speed Compound Vertical Engine.

installation there will be 300 arc lamps of 2,000 c.p. and 100 incandescent lamps in the Welcome Club. plan of the machine room given herewith show arrangement of 10 arc light dynamos of the well-k Thomson-Houston type, Fig. 1, each generating cu for 35 arcs. Thus one machine will be constant reserve. The dynamos run from 820 to 850 revolu per minute. The pulleys are 11in. diameter, drive belting from 4ft. 6in. pulleys on the shaft. The plan 2, almost explains itself. B is a battery of three D Paxman's boilers; C E, compound girder-type engine; Windsor-type engines; S P, semi-portable engines— the same firm.

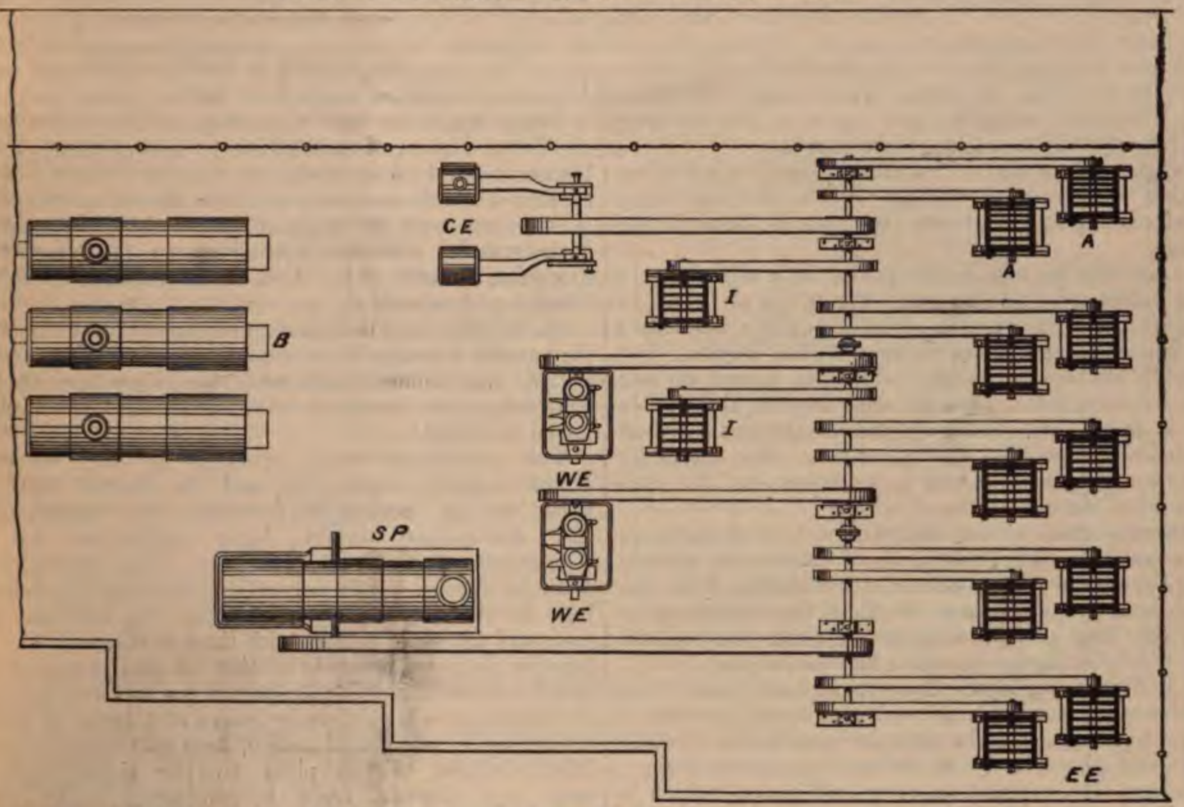
DAVEY-PAXMAN ENGINES.

The following is the description of these engines, will have to drive the whole of the machinery in the It Exhibition, which are supplied by Messrs. Davey, Pa and Co., who were so successful in the Fisheries, Invent Healtheries, and Colinderies.

The plant, in this respect, includes two of Messrs. D Paxman and Co.'s patent quick-speed self-contained ve compound engines, each of their "Windsor" type, o following dimensions: High-pressure cylinder, 11in. dian low-pressure cylinder, 17½in. diameter; both having stroke. The fly-wheel, 5ft. 6in. diameter by 11¾in. turned on the face to receive driving-belt. The engin

ted with Paxman's automatic expansion gear and adjust-
le governors. The crank-pins, crosshead pins, piston rods,
d slide rods are all of steel. Everything is of the very

FIG. 1.—Plan of Engine and Dynamo Room.—Italian Exhibition.



B Boilers. C E Girder Engine. W E Windsor-type Engines. S P Semi-Portable Engine. I I Incandescent Light Dynamos. A A A Arc Light Dynamos.

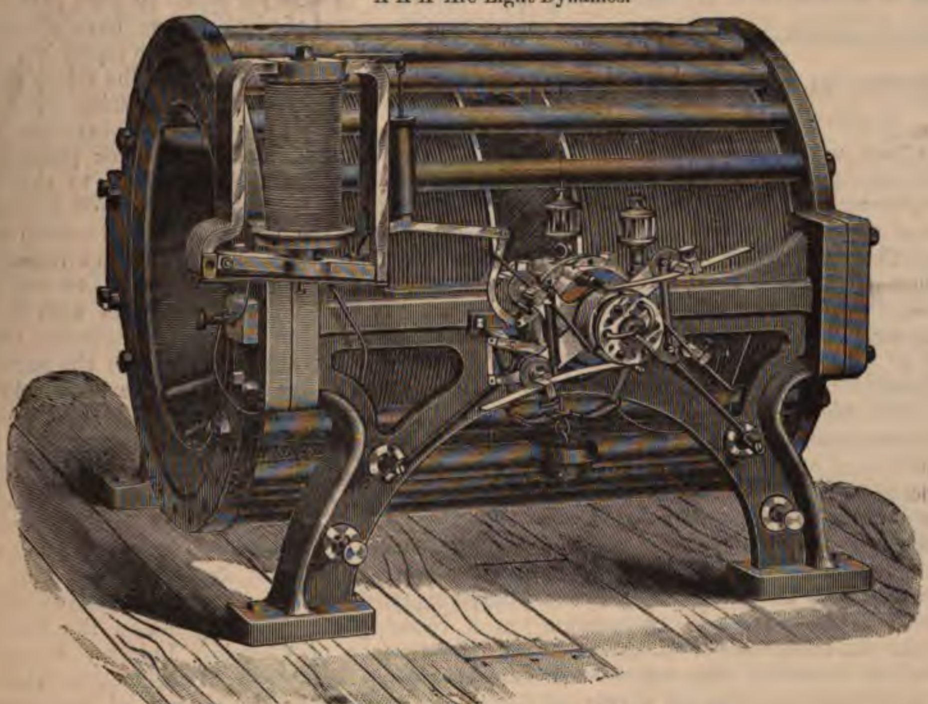
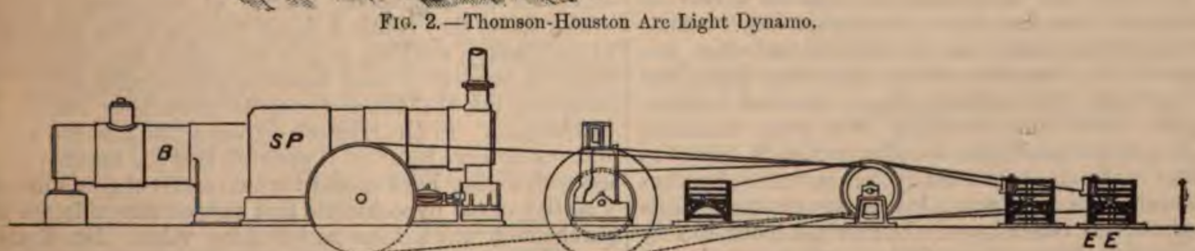


FIG. 2.—Thomson-Houston Arc Light Dynamo.



Elevation of Engines and Dynamos.

st materials and workmanship. The engines are illus-
ated by the accompanying engraving, Fig. 3. The third
gine, by Messrs. Davey, Paxman and Co., is illustrated
Fig. 4 (*see* p. 444). One improved semi-fixed compound engine, with high-pressure cylinder, 12¾in. diameter; low-pressure cylinder, 20in. diameter by 24in. stroke. The crank-shaft is steel, with cranks at right angles and accurately balanced. Heavy fly-wheel, 8ft. 6in. diameter by 17in. wide, with face turned to receive driving-belt. It is fitted with Paxman's patent automatic cut-off gear, worked direct from the governors, which ensure very steady and even

running by using only just sufficient steam for the work at the instant being performed. This is one of the very few automatic arrangements which work with regularity and certainty, and its high efficiency was proved by the remarkable results obtained at the trials of the Royal Agricultural Society last year. It may be mentioned that one of the large driving-bands on one of Messrs. Davey, Paxman, and Company's engines at the Health Exhibition suddenly broke when the engine was transmitting about 350 h.p.; but this automatic gear—even in this extreme case—prevented the engine from overrunning.

The engine is provided with a steel locomotive boiler, for a working pressure of 120lb. per square inch, all being mounted on a strong cast-iron bed-plate, as shown in the engraving.

The same firm has also in this exhibition a high-pressure coupled compound girder engine, Fig. 5 (*see* p. 444). In this engine the high-pressure cylinder is 12¾in. diameter: low-pressure cylinder, 20in. diameter × 24in. stroke. The fly-wheel is 8ft. 6in. diameter × 14in. wide, turned on face to receive driving-belt. Like the other engines, this double engine is fitted with Paxman's patent automatic cut-off gear, worked direct from the governors. Our engraving shows this engine as fitted with a condenser, but this will not be used at the exhibition.

All these engines are of neat design, and all parts are easily accessible. The special requirements for electric lighting have been well considered. For instance, all the wearing parts are very large to allow the engine to be worked for long periods without stopping, and special means for lubricating are provided for this purpose.

The boilers are Messrs. Davey, Paxman and Co.'s locomotive type, each made to work at a steam pressure of 120lb. per square inch. The shell of each boiler is made of mild steel plates, and the firebox is made of Davey, Paxman and Co.'s special improved mild steel, which is remarkably ductile, and which has given excellent results. The total heating surface of each boiler is 610 square feet.

ELECTROLYTIC BLEACHING.

The introduction of the ammonia-soda process has within the last few years considerably affected the price of production of bleaching-powder, and rendered it possible to introduce, with chances of commercial success, other forms of bleaching compounds. Among the new rivals to bleaching-powder, the process of electrolytic bleaching, devised and patented by M. Hermite, has now passed from the experimental stage, and seems to be likely to be one which may be found applicable to many industries. The electrolysis of magnesium and calcium chlorides gives, as is well known, products which have bleaching properties, and in all probability hypochlorites resembling ordinary bleaching-powder are thus produced.

During the early part of last year, Messrs. Cross and Bevan carefully examined the method of bleaching based on this electrolytic decomposition, and concluded from their investigation that an electrolysed solution or magnesium chloride possessed a bleaching efficiency of considerable excess of that of a solution of calcium hypochlorite; so that the oxidising power—*i.e.*, free in active oxygen, measured in terms of the current employed to effect the decomposition—was in excess of that calculated on Faraday's electrolytic law. They further found that such an electrolysed solution was very rapid in its bleaching action, and that there was a smaller quantity of bleaching oxygen consumed in effecting a given amount of bleaching than when bleaching powder was employed. The solution which is found to answer best in practice contained 2·5 per cent. of anhydrous magnesium chloride, and from a long series of experiments they conclude that 100 kilos of chlorine per hour can be produced by 344,000 watts, or 578 h.p., and to obtain the same amount of bleaching from bleaching-powder, 300 kilos = 6cwt. per hour of that material must be used. Prof. Pictet has confirmed these results, and Messrs. Paterson and Cooper, the joint proprietors of the process and patents, consider that these figures are sufficient to demonstrate the economy of the process. On the laboratory scale the mean number obtained for the yield of available chlorine is 1·25 grammes per ampere hour. Calcium chloride solutions do not give such satisfactory results, but since the greater proportion of the liquid is recoverable and capable of being re-electrolysed, the cost of the material is not such an important factor in the commercial success of the process. The bleaching liquid in the plant erected at the experimental station, and also at Belfast, where the process is being applied to the bleaching of Irish linen yarns, circulates from the bleaching tank, through the bleaching tank and back, so that by means of the current a continuous supply of the bleaching compounds is kept up, and a minimum of bleaching strength is entirely under control. In addition to the bleaching of flax yarn, the process has been used with success for the bleaching of paper pulp.

M. Hermite was awarded a gold medal by the technical jury at the Antwerp Exhibition, when the process was an untried one, and the results which have since been obtained have fully borne out the promise which these earlier experiments indicated.

The electrolytic tank, patented by the inventors, is of special construction, and is divided into two parts by a perforated partition, the circulation of the electrolysed liquid being maintained by the revolutions of a screw propeller. The electrodes are made of zinc and platinum, and are so situated to the openings in the dividing partition, that the solution must necessarily come in contact with them as it circulates. The positive platinum electrode consists of thin plates of that metal cast into a suitable support at the top, and the negative electrode is kept clean by means of a series of knives, which, by a mechanical action, keep continually exposing fresh surfaces of the plate to the liquid and prevent any deposit from accumulating. The anode may consist of any platinised material, or of glass or vulcanite, faced with specially pure plumbago, in the place of the plates of platinum we have alluded to. The circulation and uniform flow of the liquid is produced by a suitably arranged rotary pump. The rotary pump and the dynamo are both driven by belt-gearing from one motive shaft. In a later specification the inventors describe an improved apparatus, in which the zinc plates are made in the form of discs, and these are fixed to shafts, which are caused to revolve by worm gearing on a shaft which is connected with the motive shaft. Between each pair of zinc discs a platinum plate is held in a frame, and each is connected by an arm carrying a bolt to one pole of the dynamo. This modification dispenses with the movement of the scrapers used in keeping the surface of the zinc plates clean, which in this case are fixed on the partition in such a manner as to incline against the revolving zinc discs.

After the publication of the first series of experiments on this process, a somewhat severe criticism by Dr. Hurter (who cited experiments of his own on the same subject) threw doubt on the economic value of the method; and, more recently, Dr. Jurisch, in a communication to the *Chemische Industrie*, has obtained unsatisfactory results when endeavouring to use solutions of electrolysed calcium chloride for bleaching purposes. Messrs. Cross and Bevan have, however, in a recent paper delivered before the London section of the Society of Chemical Industry brought forward fresh evidence in support of their views, which leaves no doubt on the commercial success of the process. Their critics have, they contend, failed to satisfy the conditions of satisfactory working, as it is only when the electrolysed liquid is removed at once from the electrolysing cell to the bleaching vat, that the good results which they record can be obtained. In Dr. Hurter's experiments this precaution was not observed, and it is probable that the heating of the electrolyte may have caused the conversion of a considerable quantity of the hypochlorate first formed into chlorate and perchlorate, which have no bleaching value. Dr. Konrad Jurisch has based his calculation that one kilo of hypothetical bleaching-powder requires the energy of 18·3 kilos of coal for its preparation by an electrolytic method, as compared with only 1 kilo of coal in the Weldon process, and ·5 kilo per kilo of bleach by the Hurter-Deacon method, on his laboratory experiments, in which large Bunsen cells were the source

of energy employed. No precautions, likewise, in his investigation were taken to ensure the continuous removal of the bleaching liquid as it was formed. The authors and M. Hermite are therefore satisfied with the results which they themselves have obtained, and, moreover, during the early part of this year a complete installation of their process has been erected in America, which has more than fulfilled the expectations of the preliminary trials. The formation of perchlorate in the electrolysis of magnesium chloride solutions appears to be a question of current density, since, by regulating the size of the electrodes to the current passing, it is possible to throw the electrolysis on to the water above or on to the chlorate, as desired, and precisely similar results may be obtained with potassium chlorate. We quote from their recent paper a comparative table as to the cost of the new process compared with the cost of bleaching by bleaching-powder. The experiments were a continuation of those already alluded to, and were conducted at Belfast; and in the calculations for power expended, the estimate of ½d. per h.p. per hour is used. The mean current employed was 770 amperes at five volts.

		I.	II.	III.
Time		1h. 40m.	5 hrs.	3h. 50m.
Current		840 amp.	777 amp.	728 amp.
Indicated h.p.		7·112	6·509	6·098
		s. d.	s. d.	s. d.
Costs	Power	0 6	1 4¼	0 11¼
	Interest & depreciation	0 2	0 6	0 4½
	Magnesium Chloride	0 1½	0 4¼	0 4
		0 9½	2 2½	1 8

That is, a total of 4s. 8d. as against 14s. 4d. for bleaching-powder.

The comparison with bleaching-powder was made on the same quality of yarn, and the bleaching was continued to the same extent in the two processes.

The best results have been obtained when the size of the electrodes is such that there is a current of about ·02 amperes per square cent. We may add that Ledeboer has independently arrived at similar results while investigating M. Hermite's process as those which Messrs. Cross and Bevan have brought forward.

A totally different method of electrolytic bleaching has recently been patented by MM. Brin Frères, which, it is hoped, may be found advantageous in bleaching fibrous substances used for making paper. The patentees electrify a mixture of chlorine and oxygen, the former being generated in the usual way by the action of hydrochloric acid on manganese deoxide in a retort, and the latter is stored in a receiver. After the gases have mixed, they are washed and led into an ozone generator, in which the mixture is converted into "chlor-ozone" by the passage of a silent electric discharge. The electrified gases then pass into another vessel, in which the bleaching operation is conducted. The material to be bleached is kept thoroughly agitated throughout the process, and any excess of gas not absorbed in the material is collected in a separate receiver, and used in a subsequent operation.

ON THE PRODUCTION OF INTENSE MAGNETIC FIELDS.*

BY PROF. STEFAN.

The maximum magnetic force exerted by the cylindrical iron cores of an electro-magnet between their plane polar surfaces placed opposite to each other is $4 \pi \mu$, an expression in which μ represents the greatest magnetic moment that can be taken by unit volume of iron. If we assume that $\mu = 1{,}700$ absolute units, we have $4 \pi \mu = 21{,}360$. The smaller the distance between the polar surfaces, the nearer is this maximum value approached.

The action exerted by cores of iron at the middle of the field may be augmented without limiting the length of the latter when another form is given to the end surfaces of the cores. This augmentation attains its highest value when they have the form of truncated cones such that the generating lines of the two conical surfaces pass through the centre of the field, and make with its axis an angle, of which the tangent $= \sqrt{2}$, that is to say, an angle of 54° 44′.

The magnitude of the force is then determined by the formula :—

$$H = 4 \pi \mu \left(0{\cdot}289 + 0{\cdot}886 \log. \frac{d}{a}\right),$$

in which d is the diameter of the iron cores, a the length of the field, and log. the common logarithm. This formula allows of H being raised to any required value. This fact, however, is not of great practical importance, because the value of the logarithm increases very slowly relatively to the numbers, so that conditions of construction which cannot be realised are soon arrived at.

If $H = 8 \pi \mu$, we must take $d = 85a$.

In some optical experiments, it is necessary to perforate the iron cores. In this case, it is no longer correct to say that the nearer the polar surfaces the more intense is the magnetic field. The magnetic force at the centre of the field attains its highest value when the distance a of the polar surfaces satisfies the equation—

$$a^2 = d_0^2 \frac{n^{\frac{1}{3}}}{n^{\frac{2}{3}} + 1},$$

in which d represents the diameter of the opening, and n, the number indicating the ratio of the diameter of the iron cores to that of the opening.

The perforation of iron cores is always attended with great deformation of the magnetic field. The intensity diminishes sensibly from the centre to the extremity of the field. At this latter point the force between the plane polar surfaces is less than half that in the middle of the field. The iron cores with conical extremities above described offer also the advantage of giving, when they are perforated, a greater intensity in the middle, and a smaller diminution of force near the extremities of the field.

* Read before the Vienna Academy of Sciences, February 9, 1888.

PORTABLE ASTATIC GALVANOMETER.

The portable form of astatic galvanometer, illustrated herewith, and constructed by Messrs. Woodhouse and Rawson, is made either with a pivoted or suspended needle, and is very sensitive. It has two pairs of coils, one of high and the other of low resistance, either of which may be

fixed and put in contact by simply removing the glass cover and dial and pushing the coils into place, when they make contact automatically. The case is of brass, mounted on ebonite, with three levelling screws. A megohm resistance is included in the base of the instrument. When desired, a separate terminal is provided for that purpose, so that the instrument can be used for insulation tests. The outside dimensions are only 5in. by 2¾in. deep.

The Commercial Phonograph.—The contract for making the woodwork of the Edison phonograph and the Edison mimeograph was closed a few days since with the Gilliland Electric Company, Adrian, Mich. It is a very large one, and necessitated for its rapid execution the very latest improved machinery, which was found in the shops of the Egan Company of Cincinnati, whose woodworking tools have a wide recognition. The long-looked-for and much-talked-of "Talking Machine" will soon be placed before the public.

DAVEY, PAXMAN AND CO.'S ENGINES AT THE ITALIAN EXHIBITION.

(For details see p. 440.)

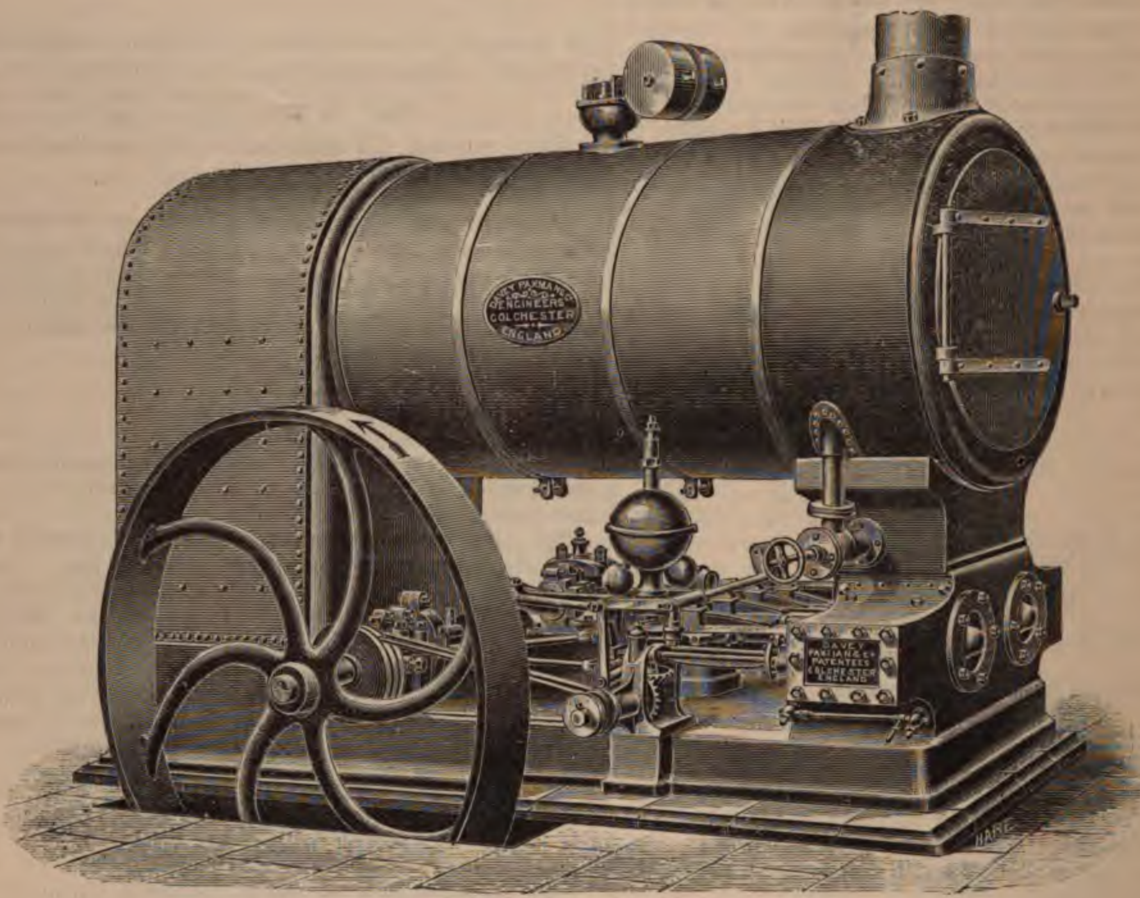


Fig. 4.—Semi-Fixed Compound Engine.

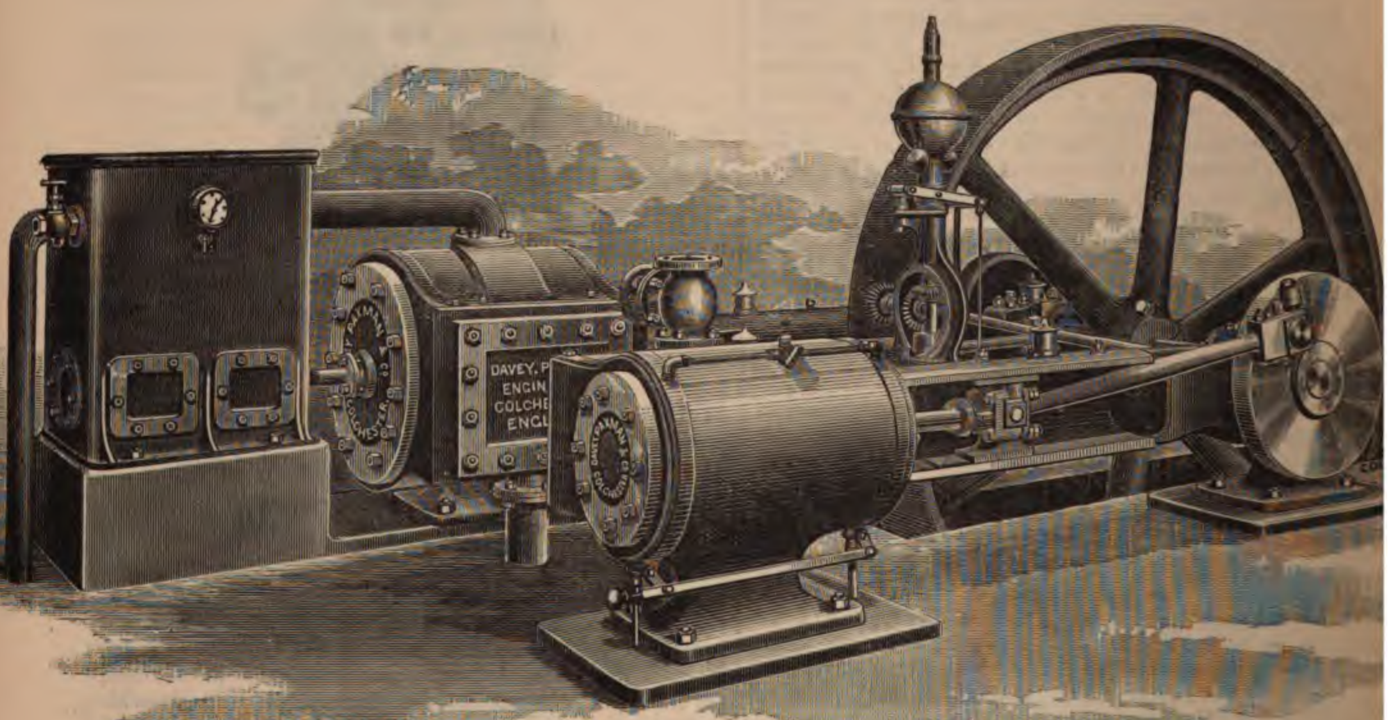


Fig. 5.—Compound Horizontal Girder Engine.

losers, will rather be gainers. There is no reason at all, except woeful mismanagement, why the principal cable companies should not pay a ten per cent. dividend with a much lower tariff. Our remarks hitherto have been general, but it may be as well to make one special reference. The chairman of one of the trust companies the other day condoled with the shareholders as to the state of their finances, pointing out that this state was wholly due to the position of some of the Atlantic companies. Now that chairman was one of the directors who put the Atlantic companies in the position they occupy, and none know better than he that the position need never have arisen and need not continue. Arbitrary and self-seeking to a degree far beyond the merits of the case, these directors have so acted that the shareholders have lost hundreds of thousands of pounds, which can never be regained. Weeks, months, nay, possibly years ago, their competitors were willing to agree to a moderate and *remunerative* tariff, though they consistently and persistently refused to put their necks under a yoke held by avowedly hostile hands. The Commercial Cable Company says that a shilling tariff is fair and that it pays, and we believe this statement to be unanswerable, those who contend it is not, dealing in what may be euphemistically termed uncertainty in veracity. The men who have caused the loss of these thousands are kept in their office simply and solely because of the control they exercise over the trust companies. And we warn America that if such companies are permitted to take root, they will be detrimental to the industry. Control means playing into the hands of those who control. Those who hold the reins do not pretend to drive through purely philanthropic motives. With them "the jingling guinea helps the hurt that honour feels"; in other words, nothing is done unless it is, directly or indirectly, going to put money into the pockets of those who control the machine. Let us see how the thing works. Suppose the Trust Company started. A, B, and C subscribe largely to the funds of the company, and are elected, or elect themselves, directors. They hold the proxies of the trust. A is made a director of an electric lighting company, and takes just enough shares to legalise his position. He is also a director in a carbon manufacturing company, in an ironworks, in a paint mill, and a dozen other concerns, because being all-powerful in a lighting company, he influences those from whom carbon, paint, iron, &c., shall be bought, and so the game continues. The shareholders at every transaction put a little money into the pockets of A in some way or other, and thus he grows rich. Verily, my masters, this game is well worth the candle. It is what will go on in America. It is what does go on in England. A deeper game is to so manipulate affairs that a five or six per cent. dividend is paid by a concern that would as easily pay ten, so that too close a scrutiny is not made into ways and means of management. A man who gets five per cent. is fairly satisfied, and does not enquire too closely whether the five ought not to have been six. Trust companies are a power in the hands of those who know how to work them with skill. It is a pity some of the masters in the art who flourish among us do not emigrate to the newer hunting ground in America. Their country would not regret their absence nor yearn for their return.

PARIS.

The municipal authorities of Paris have promulgated a series of rules to be followed in laying electric light mains and networks of service wires. The authorities are farsighted enough to see the possibility of their undertaking the supply of electric current for lighting and power purposes. It may be in addition to or in competition with the companies presently to be formed for similar purposes. Hence various important reservations are made, whereby the authorities, if they ever do proceed with the work, will obtain exceptional advantages over the companies. However, we do not find fault with those who have an eye constantly directed to the main chance—our intention being not to criticise so much as to direct attention to these rules. Our municipal authorities, or rather the engineers and surveyors to borough and other authorities, will be requested to advise as to the rules to be followed in the various localities where electric light installations for general lighting are projected. The Paris authorities deserve all our thanks for having taken the initiative in this matter, and although the rules proposed may be very imperfect, it is far easier to amend than to construct. Doubtless these rules will be attentively considered, and such alterations made as will render them suitable for places other than Paris. It will be seen that the draughtsmen of these rules assumed that the work would be under ground. There is an Association of Municipal and Borough Engineers, which meets periodically and discusses questions relating to their work. Might we suggest these "rules," or a paper upon this question, as a most suitable subject for discussion. The electric light engineers would be only too pleased to contribute of their experience towards the enlightenment of the men with whom they hope to be brought into closer contact. In all that concerns electric lighting Paris has stood in the front rank. Early in the forties, experiments were carried on in the Place de la Concorde by M. Archereau with an arc light, but, of course, the cost of the current obtained by means of a voltaic combination of two hundred pairs made such lighting economically out of the question. It was Paris that gave the electric lighting of the past ten years the filip that made it popular and possible. It seems that Paris is to pave the way in defining the connection between con-

tractors and municipalities when electric lighting becomes general.

CORRESPONDENCE.

REMINISCENCES OF THE LATE SIR CHARLES BRIGHT.

To the Editor of The Electrical Engineer.

Sir,—The very lamentable and sudden death of our much esteemed and congenial member of the electrical world, Sir Charles Bright, may have so taken your biographical writers by surprise that perhaps a few words embodying some of my reminiscences of Sir Charles may prove of interest to your readers. I was twice his principal assistant—once in 1863, until the Persian Gulf cable was laid in 1864, and again for a few months at a later period.

I can recollect many little traits of character that struck me suddenly at the time, and that showed me he had a kindly heart. I recollect once when I, in my zeal for pushing on the work of fitting out the five ships for the Persian Gulf cable, pressed Sir Charles to take some violent steps against the late Mr. W. T. Henley. "No," said Sir Charles, "I won't do that. Because we have the power of giants, that is no reason why we should use it!" I was silent for some time. I accepted the rebuke, and I hope I have ever since recollected and acted on the moral of the words, which showed a kindly and considerate heart.

Then, again, I recollect how Sir Charles used to whisper to me when we were paying out cable from the "Marion Moore" at night. "Come down below," he said, "my servant is opening a tin of Bath chaps"; and down we went, and I never enjoyed anything in the Persian Gulf so much as these little impromptu suppers which Sir Charles suddenly invited me to. Once, I recollect, when we arrived on board the P. and O. steamer, off Suez, we were absolutely starving, but so *Medes and Persian-like* were the laws of the P. and O. Company then, that, as dinner was over, we could *not get a scrap to eat.* Sir Charles was always a model of discipline, and would not even raise his voice on the subject, but determined to suffer hunger in silence so as to show an example to his impatient and excitable assistant. We paced the deck in silent hunger for some time, then Sir Charles began to suggest that we should discuss quietly what we should *like* to have for dinner. I immediately fell into the idea (I always was imaginative, if nothing else). "Julien soup," I exclaimed. "No," said Sir Charles in a grave tone, "half a dozen oysters and a glass of Chablis." "Good," I said, "I see you understand the matter better than I do, Sir Charles. But still," I said in a pensive way, "Julien soup *would not* be bad on empty stomachs like ours; however, I waive the point and accept the oysters, such as they are." "Let us get on to the fish," said Sir Charles, as we paced the deck faster and faster in the deepening twilight. "*Filet de soles au gratin* is a favourite dish of mine, Sir Charles; would you mind me having that?" "Certainly, my dear fellow, by all means; but I must have some cod and oyster sauce to follow." '*Tête de veau en tortue*' is not bad when you are nearly starving, and the stomach is in a weak state." "That is true," said Sir Charles, "but '*petits pâtés à la Victoria*' are not bad," and so we went on pacing the deck until we were obliged to turn in awfully hungry. I dreamt about that dinner, of course, all night, and then I awoke to a ship's boy bringing me a cup of P. and O. ship's coffee, and I suppose that every telegraph-engineer or electrician knows, to his own cost, what P. and O. morning coffee is. If they don't know, I advise them not to try to know, don't you know.

I believe the P. and O. have reformed since then, so enough of that story; but *I* shall *never* forget it.

Let me try to think again.

Once, when we were turning some cable over into a gunboat, about two miles off Bushire, a mistake, between myself and a young clerk, had been made as to the number of revolutions of the machine that was measuring the cable that was being transhipped to the gunboat. The mistake was discovered, and I was in consternation. We were shipping into the gunboat enough to land five shore ends. Sir Charles grasped the situation in a second, and instead of blowing me up (which "blowing up" I should probably have passed on to the real culprit, a poor harmless clerk), simply said in the coolest manner, "I will go ashore, Webb, and carry all the critics with me."

I could find in my memory, if I had time, many another small anecdote which would show the kindly feeling that existed in the heart of Sir Charles Bright.—Yours, &c.

F. C. Webb.

THE EQUITABLE TELEPHONE ASSOCIATION.

To the Editor of The Electrical Engineer.

Sir,—It having come to the knowledge of the Equitable Telephone Association that the agents of the United Telephone Company are circulating reports to the effect that the Association have not the intention or the means of defending the action for infringement of patent that the United Telephone Company have thought fit to commence against them, the Association ask the favour of your space to give these most unwarranted reports an unqualified contradiction. They also take the opportunity of stating that not only have they the fullest intention of contesting the action to the utmost, but have also every confidence that they will be successful in upholding the freedom of their telephones.—Yours, &c.,

A. A. C. Swinton, Director.

The Equitable Telephone Association, Limited, London, E.C., May 4th, 1888.

PRACTICAL USES OF THE ELECTRO-MAGNET.

The following description of the practical employment of the electro-magnet is taken from the Pittsburg *Press*:—"S. T. Wellman, the superintendent of the big steel works at Cleveland, conceived the notion some time ago that a large electro-magnet, suspended by a chain from a crane, could be employed very profitably for lifting masses of iron. Not being an electrician, he did not see his way to carrying the thing out practically. Mr. Berry, an electrical engineer of Pittsburg, being on the spot, volunteered his advice and superintendence. Together they brought the thing to completion, and it is now working with great perfection. For the construction of the electro-magnet to be experimented with, two bars of soft iron were taken, each being 14in. long and 3in. in diameter. They were wrapped with a multitude of strands of No. 14 B. and S. gauge covered wire. To combine the two separate magnets thus formed into one, they were linked together on top by a third soft iron bar, square in the cross section. For trial of the magnet at portative work, it was suspended by a rope from a pneumatic crane. Rope was used, as it was found that a chain became magnetised and did not act very well. The current power sent through the wire to induce the magnetism was that of 5½ to 6 amperes. It was found that a weight of 800lb. could be lifted up handily, and, by shutting off the current and lowering the magnet, deposited anywhere very easily. . . . At one part of the factory where this electro-magnet has been put up, fourteen or fifteen Polacks have been wont to be kept employed at this work. They are now in the position of Othello in the matter of occupation, the magnet picking up two or three billets at a time and depositing them in a car. If the thing works permanently, as it appeared to be working when Mr. Berry left Cleveland, it looks as if one boy would be able to do the work of a gang of men. His duties will be those of lowering the magnet from the crane on to some billets, turning on the current, swinging the magnet around to the top of a car, cutting off the current, and bringing the crane back to its first position. The crane used is one of a very superior class, being adapted to turning in any possible direction almost at a slight movement from a pneumatic valve. The turning off and on the electric switch, of course, would require no expenditure of energy that would be worth speaking of at all. It is intended to construct an electro-magnet of softer and more appropriate iron than that of which the first experimental one was made. The amount of current, also, will be arranged so that only a portative capacity of 150lb. or so at the poles of the combined magnet will be produced."—*Scientific American.*

THE STOCKER BOX TELEPHONE.

We illustrate this week the Stöcker Box Telephone, a form much in use in Germany, manufactured by the firm of Stöcker and Co., Leipzig. The transmitter consists of a desk-shaped case, the lid of which is formed by the iron vulcanite mouthpiece screws upon this, keeping the iron membrane tightly stretched. In the centre of the box stands the coil with its iron core. So far the Stöcker Box Telephone does not differ from other known forms, but it has its own special arrangement of magnets and pole-pieces. These are made of square steel, bent in an arc of

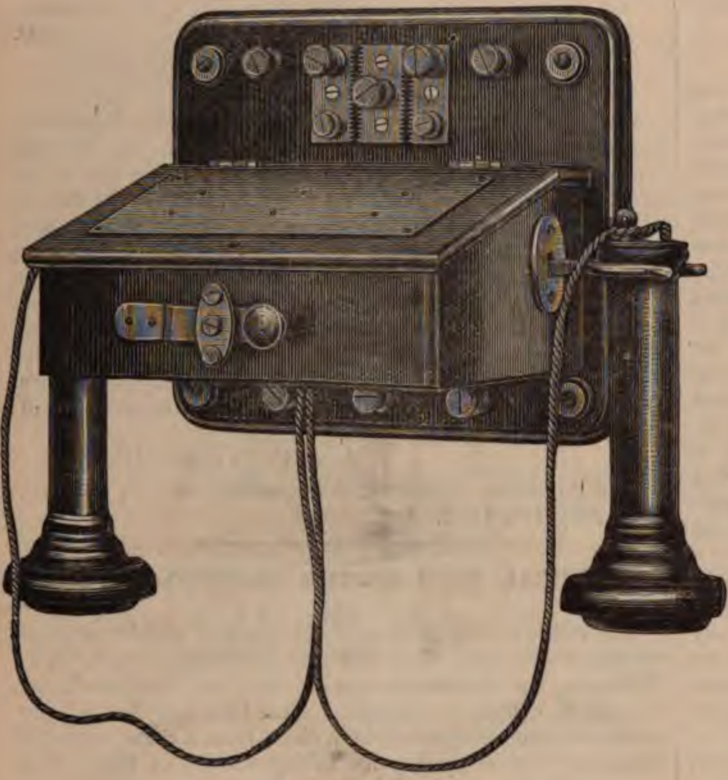


FIG. 1.

FIG. 3.

vibrating membrane. The case itself contains the microphone and the self-acting switch, and, in type 2, also the works of an electric bell. The microphone is the usual form, with two sets of five carbon rods and three connecting pieces. Fig. 1 shows this transmitter with the ordinary nearly 300deg. One pole of this circular magnet carries a connecting piece of iron in connection with the under end of the bobbin core. To the other pole a similar connecting piece is screwed, which carries a ring of soft iron bent round the outside of the coil (Fig. 3). One end of the magnet

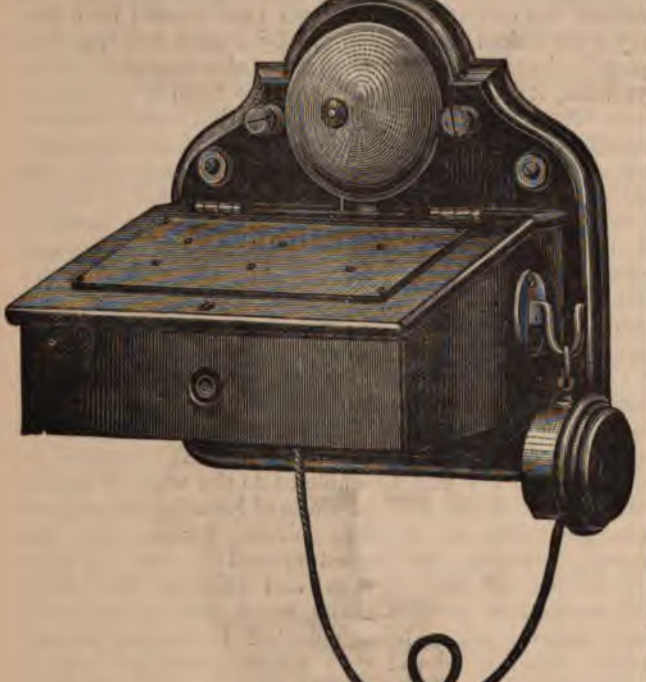


FIG. 2.

FIG. 4.

FIG. 5.

Bell receiver. The alarm in this case is fixed in a suitable place, and connected by a wire to the binding screws shown.

Their own type of box telephone has several new features. It consists, as shown in Figs. 3 and 4, of a small round flat brass box; the upper edge is threaded, and the therefore forms the central core, and the concentric ring-shaped pole, which goes round the bobbin, forms the other end. The centre of the iron membrane is by this means actuated by both poles of the magnet, obtaining thus both the strongest and the most equally distributed magnetic

effect, a condition which gives the best speaking qualities. The combination of central core poles, with ring-poles surrounding the bobbins, has, indeed, been attempted in other netic effect with the smallest space, in connection with which point it should be observed that Figs. 3 and 4 are full size, the weight of the telephone being less than ½lb.

FIG. 6.

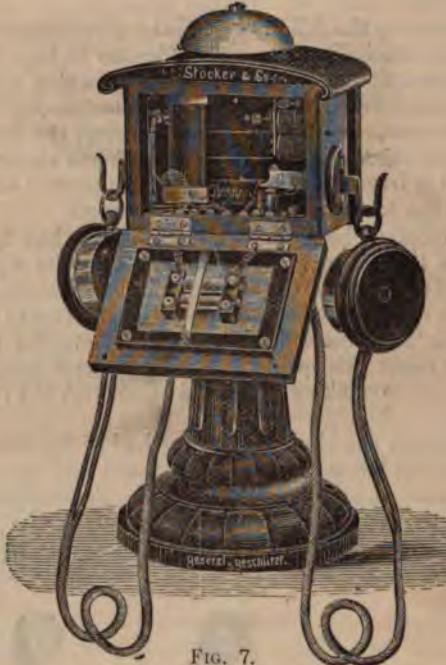


FIG. 7.

FIG. 9.

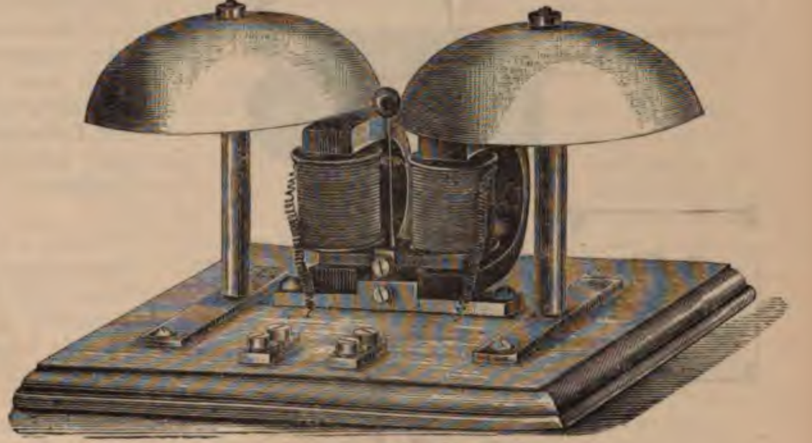


FIG. 10.

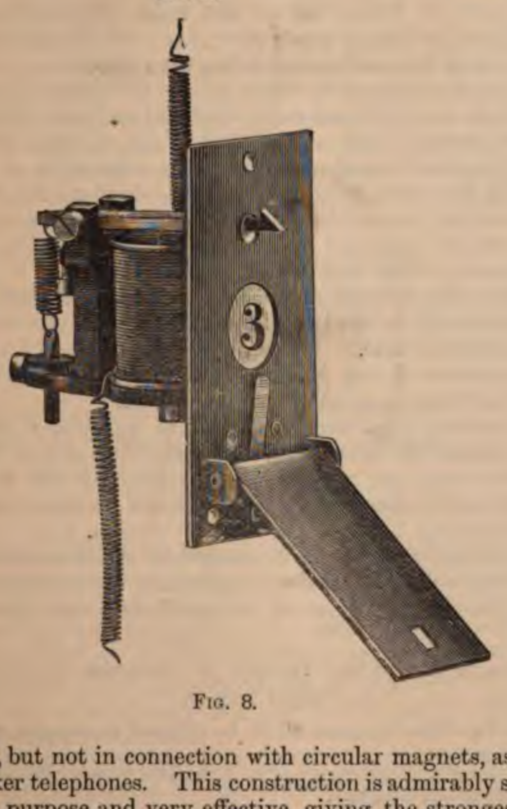


FIG. 8.

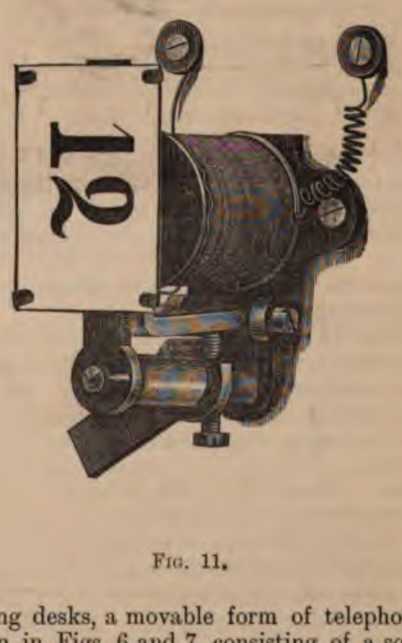


FIG. 11.

ways, but not in connection with circular magnets, as in the Stöcker telephones. This construction is admirably suitable to its purpose and very effective, giving the strongest mag-

For writing desks, a movable form of telephone is supplied, shown in Figs. 6 and 7, consisting of a square box-mounted on a pillar, containing microphone, induction coils,

switch, and electric bell. The microphone used here is the ordinary vertical arrangement.

These telephones have been greatly used in private installations, but are coming, by degrees, more and more into use for central exchanges. Of the apparatus for exchange use, we illustrate the fall-plate indicators and the contacts. Fig. 8 shows the indicator. The fall-plate is kept in position by a catch at the end of an iron arm, which forms the armature to the magnet. The further short end of this bar is pulled downwards by a short spiral spring, the tension of which can be regulated by the screw. When the armature is attracted it frees the fall-plate, which is pushed outwards by a small flat brass spring, and falls forward.

The connection between two wires is worked by push contacts, in the manner shown in Fig. 9. The wire from the fall-plate is led to the contact spring; this, as long as the push is not inserted, rests upon the underneath contact point, which is connected with earth. When the push is inserted, it raises this spring and disconnects it from earth, at the same time making communication with the required wire.

Fig. 10 shows the alternate current bell of the same firm. Two permanent horse-shoe magnets, placed side by side, are furnished with small electro-magnets on their upper poles, which are disposed in such a manner that, by the flow of the current in one direction, one of the poles is strengthened, and the other opposed; by the opposite direction of the

FIG. 12.

current, the first is opposed and the latter strengthened. Between the four poles, mounted on a axis, is a soft iron bar, on which the bell hammer is fixed. The action of these four poles is as follows: 1, 2, 3, and 4 being the four

1 2

a——o——*b*

4 3

poles, and *a b* the mounted armature, 1 and 3 will pull the armature in one direction, and 2 and 4 in the opposite. If now 1 is strengthened, and 2 weakened, the effect of 1 and 3 will overcome that of 2 and 4, and the armature will go to 1 and 3. The opposite will occur when 2 and 4 are stronger, and the armature with each change of current will move backward and forward.

Figs. 11 and 12 illustrate an electric bell indicator which differs somewhat from the ordinary construction. A single spool electro-magnet is fastened upon an iron base-plate, which is screwed to the back of the indicator-case. Under the magnet, springing out of the base-plate, are two projections; on these are two pointed screws, which act as axis to the armature. This is bent at right angles, and carries on its upper end a catch, which holds the arm of the fall piece. This arm, to which the number is fastened, is mounted on an axle, turning horizontally on a pin in the base-plate. On the other end of this is the second arm, by which the indicator is raised in the ordinary way. When the armature is attracted, the catch releases the arm, which therefore falls. The motion of the armature is controlled by the screw seen below.

ELECTRIC LIGHTING.

Proposed conditions of contract under which electric light wires may be laid in the streets of Paris :—

(Continued from page 416.)

CHAP. II.

NATURE, DURATION, AND CONDITIONS OF AUTHORISATION.—WITHDRAWAL OF AUTHORISATION.—REDEMPTION.

Duration of the Authorisation granted without Monopoly.

ART. 11. The present authorisation is granted for a period of 18 years from the date of the notice of approval, without any monopoly or privilege. The town of Paris reserves to itself the absolute right of granting other authorisations of the same kind, even within the extent of the system of ways to which the present authorisation applies.

Nature and Limitation of the Guarantee granted relative to Sites.

ART. 12. The town of Paris undertakes to reserve to the licensee, to the exclusion of all others, during the period of the authorisation, the sites reserved for his system of conductors.

It reserves to itself the right to order, and even, in case of urgency, to effect the removal or withdrawal, at the cost of the licensee, of any portion of his system of conductors whenever the interest of the public or of the municipal service renders this course expedient. The licensee will be requested at least five days beforehand, except where this may be impossible, to carry out these removals or withdrawals, and, in case he should fail in this, the town of Paris can take the necessary steps to do so at the expense of the licensee and without his being entitled to any indemnity.

Tariffs.

ART. 13. The licensee must have a uniform tariff for all subscribers to his system, provided always that this shall not exceed 0.06f. for one carcel-hour, or 0.60f. for a quantity of electrical energy supplied to subscribers equal to one horse-power per hour. The drafts of his subscription policies, in which the luminous intensities are to be referred to the carcel,* taken as unity, should be approved by the Administration after the approbation of the Municipal Council.

The town of Paris reserves the right of lowering the above given minima of prices every five years from the date of the notice that authorisation has been granted.

This revision of prices, which will be based upon the progress made in any direction by electrical industry, whether from the point of view of manufacture or of cost, will be brought forward six months before the expiration of each period of five years by the Municipal Council on the report of a consulting committee formed of four members, two of whom will be appointed by the council in conjunction with the Administration, and two by the licensee.

In case the licensee should not nominate experts, the nomination will be made by legal authority at the request of the town of Paris.

The decision of the Municipal Council will take effect from the commencement of the new period.

The policies, supplements, articles, or agreements taking effect between the licensee and his subscribers are to be in threefold copy, one copy of which, signed by the society and the subscribers, shall be forwarded to the town of Paris.

Any reduction in the tariff granted by the licensee to his subscribers will be considered as permanent until the expiration of the authorisation, and the tariffs may not again be raised.

Obligation to Accept any Demand for Subscription within the District worked.

ART. 14. The licensee shall be obliged to supply, under

* The carcel is to be determined as in the deed between the town of Paris and the Gas Company.

the conditions of his policies, electricity to any person demanding it within the extent of the system worked, except within the three last years of the authorisation granted.

He absolutely disclaims the right to insist upon the carrying out of the interior installations of subscribers.

Supervision.

ART. 15. The licensee shall be found at all times to arrange, at his expense, the installations necessary for all photometric trials and all verifications which the Municipal Council or the Administration may think fit to carry out.

Dues.

ART. 16. The licensee shall pay quarterly to the town, during the whole duration of the authorisation—

1. A sum of 100 francs per year for each kilometre or fraction of a kilometre of conduits laid down;
2. A rate of—

5%	during the	3 first years of the authorisation
6%	,,	3 following years
7%	,,	,, ,,
8%	,,	,, ,,
9%	,,	,, ,,
10%	,,	last 3 years.

on the verified receipts—verified either by the amount of the subscription policies, by the indications of counters, or by other means which the Municipal Council may elect. The above applies both to lighting and to motive power. With a view to the above, the licensee shall every quarter draw up accounts of receipts and expenditure in the course of the month following the expiration of the quarterly period. No deduction shall be made by reason of non-payments; but every cessation of subscription duly indicated by the licensee will be taken into account.

The licensee will assign to the town of Paris 15 per cent. of the profits which he may realize upon electrical installations made by him in the town of Paris without the use of the public roads.

Supplementary Dues in Compensation for Town Dues when Electricity is generated outside of Paris.

ART. 17. In cases where electricity is generated in works outside of Paris, the previous deduction on the gross receipts is to be increased by one per cent.

If the town dues in relation to coal should undergo any variation, the supplementary dues are to vary in the same proportion.

Period allowed for Payment and Obligation of the Licensee to Produce all Documentary Evidence.

ART. 18. The licensee shall pay every quarter the above-mentioned dues, within a period of eight days from the date of application for payment made by the municipal receiver. He will supply every necessary information to the functionaries or agents of the town whose duty it is to verify the accounts in relation to these dues. More especially is he to place at their disposal the books and documents which they may require.

Supervision to be at the Cost of the Licensee.

ART. 19. The expenses of the supervision exercised by the town are to be paid by the licensee, and they may be applied for within the first fortnight in January, and shall be considered due to the town from that period.

Conditions of the Withdrawal Authorisation.

ART. 20. The authorisation shall be withdrawn after notice from the Municipal Council—

1. If the licensee should transfer to third parties the whole or a portion of the rights and obligations ascribed to him in the present condition of contract, without the express authority in writing of the Prefect of the Seine after notice given to the Municipal Council.
2. If he has not commenced the working within the period of six months from the date of the authorisation, and if within a period of two years he is not in a position to satisfy any demand for electricity within his system of conductors.
3. If during the period of the authorisation he suspends the distribution of electricity, over the whole or a portion of his network, without authority from the Municipal Council.
4. If the licensee should not conform to the obligations imposed upon him in the present conditions of contract.

Any portions of the conductive system authorised to be carried out, and that shall not have been utilised within a period of two years, or which have ceased to be utilised, shall be withdrawn from the licensee.

In case of bankruptcy or failure of the licensee the present authorisation shall become null and void.

Conditions of Redemption.

ART. 21. The town of Paris reserves to itself the right of redemption at any period, after the expiration of the 10 first years of the duration. The terms of redemption shall be determined in the following manner:—

1. The mean annual nett returns obtained by the licensee during the five years preceding that in which the redemption is to be carried out shall be calculated.

These mean nett returns shall constitute the amount of an annuity, which shall be due and paid to the licensee during each of the remaining years of the duration of the present authorisation.

It shall be open to the town to redeem the remaining annuities by the payment of a capital sum representing the actual value of these annuities at a rate of interest of five per cent.

2. In regard to the system of conductors, the machines and apparatus of every description, the tools in the workshops, the furniture of the offices, the lands, buildings, &c., and generally to all things employed by the licensee in his working, the town of Paris will take them over in entirety according to their value at the period of purchase as determined by experts.

This value shall be paid to the licensee within six months following the period of purchase. In consideration of the payment of this purchase price, the licensee shall assign to the town all his rights and privileges, leases, locations, contracts for sale, &c., provided always that this assignment shall in no case have the effect of implicating the town in any actions at law or legal difficulties which may exist between the licensee and any of the third parties at the period of sale. In view of the obligations of this clause, the licensee is forbidden to alienate, or to mortgage to any person whatever, the premises constituting the property of the company or any of the installations, either beneath the public roads or any private property. The premises belonging to the licensee, but which are not yet utilised in the working to which the present authorisation applies, are excepted from this clause.

Surrender of Localities in Proper Condition at the end of the Period of Authorisation.

ART. 22. At the period assigned for the expiration of the present authorisation, the system of conductors will be the property of the town unless the latter should prefer that it should be removed, and in this case the localities shall be restored to their original condition at the expense of the licensee, under his directions or otherwise, without his having claim to any indemnity.

The above applies also in case of the withdrawal of the authorisation either for the whole or for a portion of the system of conductors.

(To be continued.)

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

CENTRAL STATION LIGHTING—TRANSFORMERS v. ACCUMULATORS.—DISCUSSION.

(Continued from page 430.)

Mr. Gordon considered that enough had been said to almost pulverise Mr. Crompton; but, probably, that gentleman would have taken a different view had he been present. The load diagrams which Mr. Crompton had produced showed clearly that in America, as in England, the period of heaviest load was about the dinner hour. The stars in their courses seemed to fight against the tranformer system, which, besides possessing inherent defects required for its success that overhead wires should be allowed to be run, that an E.M.F. of 2,000 volts

should be permitted, and that all spare gear should be omitted, so as to cut down the capital outlay to make a good comparison with the accumulator system. His experience of the absence of spare gear showed that it had a depreciating effect upon the engineer's attendants. Mr Crompton was at a disadvantage, as he could not quote actual facts without appearing to advertise his own system, which was contrary to the spirit in which papers, and the discussions upon them, should be brought before the society. He himself had no interest in any particular apparatus, and could speak with less reserve. He had entered into a contract with Mr. Crompton, dated 22nd December, 1887, which provided that eight batteries of 60 cells, and 12 spare cells, making 492 in all, should be supplied for £3,320, or £6. 15s. per cell; but, as four of such cells would equal one of the cells taken in Mr. Crompton's estimate, £27 should be taken to be compared against his quotation of £40 per cell. The normal discharge of the quarter-cell was to be 105 amperes, with a capacity of 525 amperes; the cells were to be capable of discharging at 200 amperes, with a capacity of 375 amperes; the efficiency at 105 amperes to be not less than 75 per cent., at 75 amperes not less than 85 per cent., and at 45 amperes not less than 90 per cent. Any insufficiency was to be met by the contractors at their own expense. The contract was for five years, the cells to be kept in all respects equal to new for 12½ per cent. upon the contract price. Those were actual facts which Mr. Crompton could not state for himself.

Mr. Sellon congratulated Mr. Gordon for having entered the breach as an advocate of secondary batteries. He had never heard such a one-sided discussion before at a meeting of the society. Prof. Forbes had criticised the figures given by Mr. Crompton so unfavourably as to make transformers appear, relatively, far more economical than accumulators. Overhead wires would not be tolerated in this country, and having been in the United States not many months ago, he knew that the alternating current systems there were carried out only because the Americans accommodated themselves to circumstances which were simply not admissible in England. No sane engineer would attempt to lay down overhead mains to supply an installation of 100,000 lights, and there was no experience to show what would be the condition of such a system when ramified right and left underground. Mr. Hammond's experience with alternating currents on an underground system, supplying a few hundred lights with mains a few miles long, did not enable a conclusion to be drawn as to what would occur when 100,000 lights were fed. The fact that even the most ardent advocates of alternating currents, of whom Mr. Kapp was, he thought, an instance, were prepared to adopt batteries when they were sufficiently reliable, was an absolute acknowledgment that a system based upon the employment of batteries was the ideal system, and an admission that the alternating transformer was only a stop-gap system. Secondary batteries had been subjected to much odium, and had got into disgrace on account of insufficient attention, because they did not change colour, or do anything remarkable before going wrong, and, therefore, the workmen treated them as being all right. In the hands of competent men those difficulties disappeared. He would ask Mr. Crompton what he would do in the case of an installation of 100,000 lights, as against that of 10,000 lights, which he had calculated for. Would he increase the number of local centres placed in series from a single source of supply, or have a separate generating station for every set of four sub-centres? In the former case the difference of potential would rise to something considerable, and the danger of leakage would be so great that the charging and discharging must be done at the same time; or there must be two sets of batteries as in the B.T.K. system, which did not allow of charging and discharging at the same time. If, however, a system of continuous current transformers and batteries were used, then during the period of medium demand (about one-half of the time) the whole plant would be in operation, but there would be a surplus current which would go to charge the batteries; and during the period of minimum demand the batteries would supply the necessary current. Such a system had the advantages of being able to charge storage batteries and supply motive power, and avoided the necessity of having a bulk of batteries to supply the whole of the current. Some people might regard one as a harmless imbecile for suggesting such a system, because the continuous current transformer was a revolving piece of mechanism, difficult of insulation, and all the rest of it. That was true, but such transformers would not be placed on consumers' premises; and in local centres, which were a necessity, whatever the system of distribution, it did not matter whether the mechanism was revolving or stationary. A little more attention was required by revolving apparatus, but there were compensating advantages. He was quite convinced that a battery system would be the system of the future.

Mr. Robert Hammond pointed out that the systems at Brighton and Eastbourne were not the small matter of a few hundred lights and a few miles of wire, but should more properly be referred to as consisting of a few thousand lights and 22 miles of wire, which had been in work for seven years.

Mr. Bernard Drake: I quite agree with Mr. Crompton that those of us who are connected with the manufacture of secondary batteries are much indebted to him for the way in which he has pleaded our case, but I do not think we have much to thank him for in having alluded to Mr. Hammond's work as "temporary lighting." This has brought upon the unoffending battery a perfect storm of abuse, which I cannot help thinking it would have escaped if Mr. Hammond had been left alone, especially as this gentleman has only lately put down some of this maligned apparatus for the lighting of his own house. The first question which we have to consider, in comparing the systems, is, supposing that both are working over the same area—which is to be preferred by the public? My own opinion is that the battery system would carry the day, even though 1s. per unit were charged, instead of 7½d. In the first place, they are afraid of the high-tension system, and also are prejudiced in favour of the idea of pumping into a reservoir from which you draw as required, and it appears to them, *from a common* sense point of view, that this is more reliable than depending on moving machinery. Battery systems must be divided into two distinct classes, those in which the battery is charged in the day time and afterwards separated from the dynamo and discharged on to the lamps; in this case the depreciation will amount to 15 per cent. and the efficiency to 70. The second system is where dynamo and cells are run together during the heaviest part of the lighting, when the depreciation will be about 7 per cent. and the efficiency 85 or 90 per cent. There seems to be a prevailing notion that the very presence of batteries in the installation involves the loss of 40 per cent. of all the current used in the lamps. This is not the case. It is only the current which goes into the batteries and is reconverted back again that suffers any loss. If a charging-current of 500 volts is employed, there will be no danger to life; no loss in conversion of the current used by the lamps to the full extent of the dynamo output; there can be no sudden breakdown; the station can be worked with one shift of men; and the engine constantly kept going at the point of greatest economy. Under these circumstances, I cannot but think that batteries will compare very favourably with secondary generators. The main question is the depreciation of the batteries; and I quite agree with Mr. Sellon that the past is no criterion, for they have been placed in isolated installations in the hands of people who have no idea how to use them. Batteries properly looked after will last twice or three times as long as those which are not under proper supervision. I was glad to hear from Mr. Crompton that the cells which Mr. Gorham and I made for the Vienna work, for which he made the dynamos, are doing so well, as also those which we made for Mr. Preece. There is another case to which I would refer, probably the oldest battery in London, namely, those at the P. and O. offices, the plates for which were made even before we became connected with the Storage Company. These cells have lasted four years, and are now in perfect order, a result entirely due to the way in which Mr. Hall, the engineer, has looked after them. That batteries can be seen which have worked in this way clearly shows that they can be relied upon under certain conditions, but for the present I do not agree with Mr. Crompton that in first cost and maintenance they can be made to compare with the secondary generator system. Where expense is the main object, the district is spread, and large halls have to be lit more than private houses, the alternating system will undoubtedly be most used, but I do not attach much importance to the fact that in America the transformer system is the only one which has made any way, for the Americans have practically only one company who are devoting themselves to making secondary batteries, and they came over to England only a year or so back to learn how to make them. If the same amount of brain and time had been expended on batteries in America as on transformers, we should no doubt have heard from Prof. Forbes of the hundreds of tons of batteries he saw, as well as the large quantities of transformers. Automatic contrivances will, no doubt, be useful; but I see no reason why the system should not be started without them, provided the cells are put in central distributing depots, for the man in charge can easily switch the batteries in and out by hand, as required. In America one sees five or six large engines and dynamos side by side; but it has never been stated that the station could not succeed because the engines do not start and stop automatically according to the work in the lamp-circuit. Finally, I am of opinion that both systems can be made to work quite satisfactorily, and to pay their way; but I am convinced that the question as to which system is most largely adopted for the next few years in England will depend very much more upon the engineers than upon the system itself. Whichever gets the best men in the early days will become fashionable, and more time will be devoted to its development. If the battery system only receive the same attention as the secondary generator system, and good practical engineers are interested in its development, I cannot but think that the battery system will hold its own both now and in the future.

Mr. Frank King, as the first man in England who put a system of secondary battery distribution into practice, at Colchester, had read Mr. Crompton's paper and listened to the arguments with much interest. Mr. Crompton might have utilised a higher tension for his charging arrangements. He had himself used at Colchester an E.M.F. of 1,250 volts for two and a half years without hitch or difficulty, and the cables when taken up were as perfect as when laid down. At the residence of Baron Rothschild, 535 volts were supplied through a mile of charging cable, underground, without trouble as regards insulation. Mr. Crompton's provision of only four subsidiary stations was too little. At least 10 battery stations were required; though for an area like Kensington probably six would do, but certainly not four. He was a strong advocate of the storage system, and his experience was that reliance could not be placed on the continuous running of any dynamo machine. The system must be such that the consumer should always have his maximum light available, and there should be no risk that the dynamo might fail at the moment of maximum load. All statements in regard to the durability of storage batteries were based upon batteries which possessed inherent defects, but there was not the smallest reason why a battery should not be made in which it would be absolutely impossible for any wasteful internal action to take place. The deposit of 1lb. out of 16lb. active material mentioned by Prof. Forbes was beside the matter altogether. They did not put just enough active material into the cells to give the durability wanted; sometimes it was four or five times as much. Engineers who proposed using storage batteries would come to grief if they attempted to charge a number of them in parallel. Storage cells must be charged in series so that they should all receive an identical charge. He agreed with Mr. Crompton's proposal to use brick trenches, for he had used them at Colchester, and they remained as good as when first laid.

Mr. Stuart Russell pointed to successful instances of underground cables having been laid. Early failures were due to insufficient insulation, and the cables were often defective before a current had been sent through them. Underground cables were used for the A.T. system in Philadelphia, which had not been referred to by Prof. Forbes, and it was stated in a recent discussion at Pittsburg that some fifteen miles of

underground conductors were working with very satisfactory results with the alternating-current system. At Milan, cables were used for 1,500 volts continuous, and 2,000 volts alternating-current circuits. In the sewers in Brussels some five miles of cables worked satisfactorily with 1,400 volts continuous current. The Colchester and Eastbourne cases had been already referred to. At Silvertown, their experience of underground circuits extended for five years, the positive and negative conductors for arc light circuits lay together in the same trench, and no repair had been necessary at all to the cables. If a high-tension system of any sort were used, no doubt present knowledge would enable it to be put underground in such a manner as to give satisfactory results. He considered that Mr. Crompton had been too liberal in his allowance for copper for his mains.

Mr. C. T. Fleetwood said that brick subways 18 inches square were not possible in London streets. It was frequently difficult, from the presence of supply pipes of various kinds, and owing to coal shoots and cellars, to put down 3in. pipes. His experience convinced him that iron pipes containing well-insulated conductors was the best system practicable for the vast City of London.

The discussion was then closed, and the President announced that Mr. Crompton would reply on May 17th.

Correction.—In the report of the speech of Mr. W. B. Esson, in last week's issue, he asks us to correct as follows: For "distribute from four centres at an aggregate of 600 volts," read "distribute from four centres an aggregate current of 6,000 amperes"; and for "two systems of distribution before them, one by mains at low potential, 100 volts, and the other at high potential, 2,000 volts," read "two systems of A.T. distribution before them, one from a few transformers by distributing mains at 100 volts, the other by transformers in each house with a high potential charging network at 2,000 volts."

PARLIAMENTARY INTELLIGENCE.

COAST TELEGRAPHS.

In the House of Lords, on Friday, April 27th,

The Earl of Morley rose to call attention to the report of the committee appointed by the Board of Trade to inquire into the desirability of electrical communication between light-vessels and outlying lighthouses and the shore. He said that an interesting discussion on this important question had been recently held at a meeting of the Associated Chambers of Commerce, and at a meeting of the Plymouth Chamber, of which he was a member, a debate had been held on the question, which was well worth attention. The committee has dealt exclusively with lightships and lighthouses on the Thames, though the recommendations of some Chambers of Commerce went so far as to urge that cables all round the coast should connect all the lighthouses with the General Post Office system. That, however, would probably involve too great expense. He hoped that the Bill which he believed was shortly to be introduced would enable Lloyd's to purchase sites for their signal stations. Where there were communications by rockets or guns, the rockets might not be seen and the guns might not be heard, particularly in the case of fogs. He need not dwell on the enormous importance of time in these cases. A few hours, often a few minutes, made all the difference between absolute disaster and the saving of life. He quoted from the experience of the coxswain of the life-boat at Ramsgate to show the inestimable value of telegraphic communication, and that under the present system of rockets a wreck might lie for many hours in great peril, without those on land, 20 miles away, knowing anything about it. He particularly mentioned the case of the "Indian Chief," which got aground early in the morning. In this instance, telegraphic communication would have been of the greatest importance. He though it would be sufficient to read one paragraph from the evidence of Captain Plover, who mentioned that telegraphic communication would have been the means of saving hundreds of lives. The superintendent of the telegraph department of Lloyd's gave a number of instances in which telegraphic communication would have saved lives. In the case of the "Schiller," lost about 15 years ago, 331 lives were sacrificed, and the coroner's jury gave it as their opinion that if there had been electric communication the vessel would have been saved. He also mentioned a case off the coast of his own county, where a vessel which was wrecked might have been saved if her state had been known in time. This system had been adopted in Canada, where telegraphic communication was used for commercial purposes, as well as in North Germany, where the lighthouses were connected with the shore, in Denmark, and, he thought, in Sweden and Norway. He was not anxious now to urge on the Government a great expenditure, but he wished to insist that the question should not be lost sight of. He hoped that they would hear that there would be a gradual extension of the system. The country at large was interested to an extraordinary extent a year or two ago in the subject of the saving of life at sea, and he ventured to think that, without incurring very large expense, communications might be established between certain prominent lightships and also outlying lighthouses and the shore by means of the appliances of modern science. He hoped the subject would be seriously considered by the Board of Trade, and that gradually and cautiously the system would be extended.

The Earl of Onslow remarked that the subject to which the noble earl had called attention was one which interested a very large and important body in this country—namely, the mercantile marine. At the outset it was important to call attention to the terms of reference of the committee. It was appointed with the special object of facilitating the saving of life at sea, and the reason for that reference was that the funds which the Government were enabled to devote to that purpose could only be derived from one source, and that source was the Mercantile Marine Fund. Now, by the Merchant Shipping Act of 1854 it was provided that the Mercantile Marine Fund should be applied to the Local Marine Board and purposes connected with it, the expenses of surveyors of steamships, expenses of lighthouse authorities, lastage and ballastage of the Thames, expenses of wreck receivers, the preservation of life and property from and in case of shipwreck, any expenses specially charged by Act of Parliament, and "for no other purpose whatever." Therefore it was quite impossible to apply any portion of the Mercantile Marine Fund for the purpose of establishing electrical communication around our shores. If it was desired to do anything in that way in the interests of commerce, the fund must be provided by shipowners themselves or by the Post Office, who were bound by Treasury regulations to incur no expenditure which would not either prove remunerative or be guaranteed by those deriving benefit from it. Apart, however, from the question of cost, there was a question of danger to the lightships themselves, because if masters were able to make communications with the shore through the lightships, the number of vessels which would approach to the lightships would increase from an average of six to probably 20 a day, with the consequent risk that the lightships might be run down and a dangerous shoal or sandbank left absolutely unprotected. It was the duty of the Board of Trade and the lighthouse authorities to see that expenditure for this purpose was devoted in the first place to the prevention of wrecks, and not to offering temptations for lightships being approached for signalling purposes. A few years ago the lighthouse dues were very largely reduced, and the bad trade had caused a further falling off. The consequence was that in 1886 it was found necessary to borrow for the purposes of the Mercantile Marine Fund the sum of £250,000 from the funds of Greenwich Hospital. In 1886-7, £100,000 of that sum had to be expended in order to make up a deficiency between receipts and expenditure. Taking the accounts for 1886-7, the last completed, as representing the annual expenditure and as a basis of comparison, the deficiency might be taken at £160,000, being £68,000 in excess of dues for maintenance of lighthouses and new works, and £92,000 in excess of income upon other branches of the services—namely, mercantile marine offices, surveys of ships, expenses of saving life on the coast, and relief of distressed seamen abroad. The receipts from light dues had increased by £12,000, but as the accounts of the lighthouse boards for only six months for the current year, 1887-8, had been as yet received, he had obtained from those boards an estimate of their expenditure for the succeeding three months to December 31, 1887. This information led to the conclusion that the deficiency for the whole year 1887-8 might possibly not exceed £110,000. During the last ten years there had been an average of about £50,000 expended on new works. In the unfortunate state of the Mercantile Marine Fund the Board of Trade had done all they could to reduce the expenditure on new works, but they had not been able to reduce it below £85,800. The reason of this was that in these days shipowners, and perhaps shipmasters, were tempted to drive their ships by lights instead of, as in times past, navigating them by the lead. Consequently demands would continue to be made for illuminants of higher powers, for fog signals emitting increased volumes of sound, and other appliances which inventors were not slow to urge the Board of Trade to adopt. As things were, the means of signalling ships coming to our ports were very considerable, and shipowners had no great difficulty in obtaining early information regarding the approach of their vessels. It was a difficult and expensive task to establish communication between isolated rocks and the mainland, but experiments were now being carried out by Lloyd's in this direction, and if those experiments were successful, there was reason to hope that the system of communication between outlying rocks and the land might be very largely made use of. For vessels coming up the east end of the Channel there were ample means of communication, as there were stations at Dungeness, Beachy Head, two at Dover, and one at Deal, while it was under consideration whether there should not be another at the North Foreland. Vessels approaching the Thames from the north were reported at Southend Pier, and it was contemplated to establish a station at Orfordness, which vessels approaching the Thames could hardly miss. For the east coast north of the Thames there were Flamborough, Yarmouth, Grimsby, and Aldborough. With regard to the experiments which had been made at the Sunk lightship, they had been very costly. The ship cost £7,000, without the fog signals; but for the purposes proposed this vessel would be too small, and it would be necessary to build another costing £8,000, while the cost of maintenance would amount to £2,420 a year, exclusive of £4,000 for the cable. What had been the practical results of the Sunk experiments? Since its establishment the ship had only called the lifeboat out seven times by telegraph, and on every one of those occasions the lifeboat had been apprised earlier by the rocket signals. It must be remembered that it was not possible always to have a man watching the shore end of the cable; he might be in bed, and only be called up by the ringing of the bell, and then he would have to go out to give the message. It was true that there was one advantage of communication by cable—namely, that it might prevent the lifeboat from going out on a futile errand after the wreck had been got off; but he must point out that the lifeboat men were paid for every time they went out, 10s. in the day, and £1 at night. It had been argued that by having cable communication, those on shore were able to know the exact locality of the wreck; but it must be remembered that rockets were fired in the direction of the wreck, and consequently the lifeboat men were able to form an accurate idea as to where the wreck was lying. It might be the case that cable communication would have been of advantage in the case of the "Deutschland" and the "Indian Chief," but there the want had been not so much of communication between lightship and shore, as that there was no ship at all at the most important point. Since that time a ship had been placed there, and only one casualty had occurred since. To establish cable communication was a very expensive matter. A light cable chafed, while with a heavy one there was the risk of the ship's anchor fouling it, and the ship sheering on to the lightship and causing it considerable damage. The experiments, there-

fore, at the Sunk hardly justified further expenditure in the same direction. The Mercantile Marine Fund was in a state approaching bankruptcy, and could not be saddled with further burdens, while shipowners were not ready to come forward themselves. Lloyd's and the *Shipping Gazette* had done much to prevent loss of life at sea by supplying early information, and he trusted that the Bill shortly to be introduced by Lloyd's might pass through Parliament that Session; at all events, it would meet with no opposition on the part of the Government. He held that it was the duty of the Government with respect to this question rather to prevent wrecks than to give information after they had taken place, to spend their funds upon maintaining the efficiency of our existing lightships, and then, if anything further was possible, to increase the number of those ships. He could not, therefore, hold out to the noble earl that there was any chance of the Government taking up this question at present.

The **Earl of Crawford** said that he had been disappointed in the report which had been sent to the Board of Trade by the committee appointed to consider the question of saving life at sea, and he had himself desired to send a fuller report, recommending that further experiments should be carried on, but in a different manner. He was, however, bound to be guided by the opinion of the remainder of the committee, and he had therefore been unable to give effect to his views. He was all the more pleased, therefore, that their lordships' attention should be called to this subject. He agreed with the noble earl opposite that the committee had been rather too guarded in the expression of their views. There had been several matters which they had wished to recommend, but they had been informed that the present state of the funds at the disposal of the Board of Trade prevented any possibility of carrying out such suggestions. He believed that much would be done by the Bill which Lloyd's had promoted last session, in which they engaged to transmit information of wrecks to the nearest lifeboat station. He was happy to say that the experiments which had been tried showed that it had been found possible to maintain electric communication between the shore and the lightships. Those experiments had been continued throughout the winter with the most satisfactory results. The noble earl had said that the cost of maintaining that communication was very great; but, on the other hand, the value of service rendered by means of that communication ought not to be overlooked. He thought that it would be in the interests of the lightships themselves that they should be of a larger type. It had been found that, while the men on board the lightships off the coast of Ireland could see for miles around them, at night the coast was hidden by fog, and no signals made on the ships could be seen from the shore. In these circumstances telephonic communication between the ships and the shore would be of the utmost value. He did not advise that lightships should be made the medium of communication between passing vessels and the shore, because that might lead a vessel into too close proximity to the lightship, and thus cause danger to both Lightships were placed in their positions for the purpose of warning vessels to keep away, and not for the purpose of attracting them into positions of danger.

Earl Granville said that there had been too many objections—good, bad, and indifferent—offered by the noble earl in his reply to the observations of his noble friend. He was aware that the Government were exercising the strongest possible supervision over the expenditure of the country, but at the same time, in the matter of saving life at sea, he thought, even if the Mercantile Marine Fund was, as had been alleged, almost insolvent, the difficulty of want of funds for that purpose might be overcome by making an application to Parliament. It was stated on behalf of the Government that experiments had been tried with regard to electric communication between the shore and lightships, and that it had been found impossible to keep the cables in continuous good working condition. He understood, however, that the noble earl who had last spoken took exactly the opposite view of the matter, and that the experiments had proved successful. However that might be, the experiments ought not to be dropped, and he hoped that the Government would give the House an assurance that they would consider the subject further instead of finally putting it on one side.

TELEGRAPHISTS.

Mr. O. V. Morgan asked the Postmaster-General, on Tuesday, whether there were at present in the metropolitan districts twenty-five first-class telegraphists, whose length of service ranged from eighteen to twenty-four years, who had been waiting at the maximum of their class since April, 1886; whether it was his intention to increase the senior class so as to relieve the congestion which at present existed, and which must necessarily increase yearly as others arrived at the maximum; whether, in the Central Office, the number of senior telegraphists was 161, as compared with 334 first-class, while in the metropolitan districts the numbers were sixteen and sixty-one respectively; and whether he would take the necessary steps to remedy the inequality?

In reply, **Mr. Raikes** stated that the number of the first-class telegraphists in the metropolitan district who have attained to the maximum of their scale of pay is 24, and they reached their maximum in 1886. Of these 24 officers, 15 have completed 18 years of service and nine have not. The numbers of the respective classes are as stated by Mr. Morgan. The difference is due to the comparatively much larger number of superior duties performed in the Central Telegraph Office. The numbers of the classes both in the Central Telegraph Office and in the metropolitan district are fixed strictly in accordance with the numbers of superior duties to be performed, and as there are at present no additional duties of the kind to be provided for in the metropolitan district, he did not feel justified in making an addition to the senior class.

Mr. Tuite asked the Postmaster-General whether he could now state if the estimate of £40,435 for the first class at the Central Telegraph Office for the past financial year was not realised by over £7,000; whether there were over 100 vacancies in that class; and whether he would consider the desirability of utilising the whole of the estimate of £41,252 for the current financial year by at once filling up those vacancies.

In reply, the answer given a few days ago was repeated, that the charge for the salaries of telegraphists of the first class at the Central Telegraph Office in the past financial year will not fall short of the estimate to the extent of £7,000. There are at present 70 vacancies in the class. As regards the current financial year, promotions will be made in due course, and that the expenditure for salaries of telegraphists at the Central Telegraph Office will approximate very closely to the estimate.

COMPANIES' MEETINGS.

SUBMARINE CABLES TRUST.

The seventeenth annual general meeting of the certificate holders of the Submarine Cables Trust was held, on Tuesday last, at the Winchester House, Old Broad-street.

Sir James Anderson presided, and in moving the adoption of the report stated that the revenue for the financial year ended the 15th ult. has been £17,948 as against £14,528 for the previous year, but in 1887 they brought into the accounts £2,140, whereas they began the year under review with only £95. In both years they had paid their coupons at the rate of 4½ per cent., but they carried forward to the current year a balance of £1,448, which was equal to an additional 8s. 6d. per cent. The interest payable on their certificates was cumulative, but their revenue had not enabled them to pay the coupons beyond those due on October 15, 1887, leaving the last coupon in arrears. If they distributed at once the balance of 8s. 6d. per cent. which they had in hand, the April coupon would have to be paid in three instalments, because in October next they would not have sufficient funds to pay the whole outstanding £2. 11s. 6d. To avoid the inconvenience of paying one coupon by three instalments, the trustees proposed, with the approval of the certificate holders, to hold the money in hand until October 15, when they would pay £2. 10s., and the balance of 10s. would be met on January 15, 1889. On April 15 next year they would pay as much as possible on the October coupon. The falling off in their receipts in the past year had been mainly owing to their investment in Anglo-American Company's stock. The Eastern and Eastern Extension Companies, however, in which they held a large amount of stock, were paying very fair dividends, and by that fact their revenue was maintained better than might be expected. Eventually, if all the Atlantic cable companies came to some agreement, the Company would be in an improved position.

Viscount Monck seconded the motion, which was carried unanimously; and the auditors were afterwards re-elected.

MAXIM-WESTON ELECTRIC COMPANY.

An extraordinary general meeting of the Maxim-Weston Electric Company, Limited, was held last Thursday at the City Terminus Hotel, having been convened by the Chairman of the Company, Mr. Hugh Watt, M.P., "to elect two additional Directors and to fix the remuneration of the Board."

Mr. Watt took the chair, when the question of the validity of the meeting was at once raised and was warmly contested, the **Chairman** referring to a legal opinion which he had obtained on the question, and **Mr. J. M. Klenck, Mr. John Newton,** and other shareholders disputing the point.

The **Chairman**, after considerable discussion, stated that, though he held an overwhelming majority of proxies which would carry any resolution he might put, he was quite willing not to use them if the shareholders thought that the meeting was irregularly constituted. He was, he said, most anxious to promote the interests of the Company, in which he stood to lose between £4,000 and £5,000.

Eventually, further discussion arising as to the legality of the meeting, and the proceedings becoming uproarious, the Chairman declared it dissolved.

A meeting of the shareholders was afterwards held, Mr. Klenck in the chair, but the reporters were asked to withdraw.

From a letter by Mr. W. Klenck, sent to the *Financial News*, we gather that, after Mr. Watt had vacated the chair, it was resolved to lodge a requisition with the Company to call an extraordinary general meeting of the shareholders. The requisition was opened, and by numerous shareholders representing a large part of the capital of the Company.

PROVISIONAL PATENTS, 1888.

April 27.

6237. **Improvements in jars or cells for primary or secondary electric batteries.** Adam Millar, 62, St. Vincent-street, Glasgow. (Complete specification.)

6270. **Improvements in clips for attaching or fixing insulators to telegraph poles.** Howard Cochrane Jobson, 7, Staple Inn, Middlesex.

April 28.

6314. **Improvements in or relating to dynamo-electric machines.** Joseph Platt Hall, 17, St. Ann's-square, Manchester.

6322. **Improvements in galvanic batteries.** Paul Raoul de Faucheux d'Humy, 23, Southampton-buildings, Middlesex.

6344. **An improved means of conveying telegraph, telephone, and similar wires.** Walter Davies, 54, Fleet-street, London, E.C.

APRIL 30.

6373. **Improvements in electric batteries.** Louis Dill, Berlin, Germany, 38, Alexander Str.

6382. **An improved electric automatic delivery box.** William Miller, 13, Camera-square, Chelsea.

6390. **Improvements in electrical switches.** William Mackie and Sidney Sharp, Connaught Mansions, Victoria-street, London, S.W.

MAY 1.

6416. **Improvements in galvanic batteries.** Louis Hoppe and Günther Hoppe, 6, Annette-road, Loraine-road, Holloway, London, N.

6481. **Improvements relating to the electrical transmission of power, and to apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Nikola Tesla, United States.) (Complete specification.)

6502. **Improvements relating to the generation and distribution of electric currents and to apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Nikola Tesla, United States.) (Complete specification.)

MAY 2.

6578. **Improvements in incandescent electric lamps.** James Yate Johnson, 47, Lincoln's-inn-fields, Middlesex. (Charles Philippart, France.)

MAY 3.

6609. **Improvements connected with mechanical telegraphs for use in navigable vessels.** William Chadburn, 15, Water-street, Liverpool.

6610. **Improvements in and connected with pneumatic telegraphs for communicating between one position or station and another or others on navigable vessels and other structures.** William Chadburn, 15, Water-street, Liverpool.

6613. **Automatic resistance for electric-light circuits.** Samuel Miller, 1, Langton Cottages, Melbourne-square, Brixton-road, S.W.

6614. **Improvements in the electrical illumination of clock dials and apparatus in connection therewith.** Ernest George Craven, 4, Little Moorfields, E.C.

6617. **An improved method of printing from strips of electrotype or stereotype, and of adjusting and fixing the same upon printing blocks.** John Bell Allen, 2, Gresham-buildings, Guildhall, London.

6627. **A combined generator of electricity and electric lamps.** George Antoine Tabourin, 4, South-street, Finsbury, London, E.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MAY 18, 1887.

7235. **Improvements in the safety mechanism or cut out of electric arc lamps or other electrical apparatus.** Frederick Carrington Phillips and Hugh Erat Harrison, 2, Victoria Mansions, Westminster.

MAY 28, 1887.

7834. **Improved means for controlling, transforming, regulating, synchronizing, and registering electric currents.** Henry Edmunds, 47, Lincoln's-inn-fields, London, W.C.

JUNE 8, 1887.

8214. **Improvements in telephone systems.** William Phillips Thompson, 6, Lord-street, Liverpool. (Emil Mauritius, Germany.)

JUNE 29, 1887.

9256. **Improvements in and apparatus for regulating the speed of dynamos employed on railway trains for lighting the same.** Judah Levy Yuly and Herbert Walter Andrews, 9 and 10, Southampton-buildings, W.C.

JULY 2, 1887.

9396. **An apparatus for preventing or detecting the use of pieces of lead, iron, or other similar or extraneous substances instead of coin in operating automatic weighing, measuring, strength-testing, electric, or other automatic supply machines.** William Ernest Richardson, 19, High-street, Sheffield.

SEPTEMBER 27, 1887.

13,069. **Improvements in or relating to harmonic telegraphy.** François Van Lysselberghe, 433, Strand, London, W.C.

OCTOBER 17, 1887.

14,062. **Improvements in automatic medical electrical apparatus.** Edgar Pullar, Gray's Inn Chambers, 20, High Holborn, London, W.C.

NOVEMBER 14, 1887.

15,537. **Improvements in electric switches.** Robert William Paul, 10, Ravensdale-road, Stamford Hill, London.

DECEMBER 10, 1887.

17,047. **Improvements in secondary batteries.** Frank King, 47 Lincoln's-inn-fields, London.

JANUARY 4, 1888.

137. **Improvements in apparatus for producing induced electric currents.** John Charles Pürthner, 12, Mariahilfer Strasse, Vienna, Austria.

FEBRUARY 29, 1888.

3075. **An improved clutch for regulating feeding rods in electric arc lamps.** Alfred William Southey, 1, Cullum-street, City.

MARCH 2, 1888.

3215. **Improvements in electric incandescent lamps.** John Wm. Oldroyd, 8, Quality-court, London, W.C.

MARCH 2, 1888.

3235. **Improvements in multipolar dynamo-electric machines.** George Miot, 46, Lincoln's-inn-fields, London, W.C.

MARCH 20, 1888.

4277. **Improvements in electro-mechanical movements.** Alfred Julius Boult, 323, High Holborn, London, W.C. (James Francis McLaughlin, United States.)

APRIL 3, 1888.

4929. **Improvements in magneto-electric generators.** Webster Gillett and George Haseltine, 52, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1886.

*2956. **Electro motors and dynamo machines.** M. Immisch. 8d. Amended specification.

1887.

6104. **Electrical measuring instruments.** A. Le N. Foster and Andersen. 8d.

6219. **Induction apparatus.** J. Swinburne. 6d.

7184. **Electric arc lamps.** W. Mackie. 8d.

7950. **Telephones.** D. J. Smith and H. F. Jackson. 8d.

7892. **Telephonic instruments.** C. L. W. Fitzgerald. 11d.

8159. **Electric telegraphic communication.** W. Smith. 8d.

1888.

2179. **Incandescent electric lamps.** M. Wheeler. 6d.

2246. **Dynamo-electric machines.** H. H. Lake. (Eickemeyer.) 1s. 1d.

2250. **Printing telegraphs.** J. H. Linville. 3s.

2308. **Dynamo-electric machines.** C. Coerper. 4d.

NEW ELECTRICAL COMPANIES.

United Kingdom Telephone Union, Limited.—Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, London, E.C., without articles of association, and, therefore, the clauses of the first schedule of the Companies Act, 1862, will apply. Capital, £10,000,000, divided into 2,000,000 shares of £5 each. Object: To acquire upon any terms and for any purpose the whole or any part of the property, business, goodwill and undertaking of any company, association, or person in the United Kingdom, or elsewhere, carrying on, or in the case of a company or association formed or empowered to carry on, any business comprised within the objects hereinafter mentioned, and to undertake all or any of the liabilities or obligations, and to compensate any office, officer, or employé of any such company, association, or person, to acquire and hold or dispose of the whole or any part of the shares, stocks or obligations of any company, any property of which shall be acquired by the Company, or which may be carrying on any business, or formed or empowered to carry on any business, comprised in the objects of the Company; to acquire and exercise any patent rights, privileges, licenses or monopolies relating to telephones or any telephonic apparatus; to take and work any license for the use of any invention which may be capable of being used in connection with any business of the Company. The first subscribers are :—

	Shares.
J. Brand, chairman of the United Telephone Company, Limited, New Broad-street, E.C.	1
J. S. Forbes, deputy-chairman, Garden Lawn House, Chelsea Embankment, S.W.	1
J. Thompson, chairman of the Lancashire and Cheshire Telephone Exchange Company, Limited, Riversdale, Wilmslow	1
R. N. Jackson, chairman of the National Telephone Company, Limited, Ashurst, West-hill, Sydenham	1
J. Wistanley, chairman of the Telephone Company of Ireland, Dundrum, co. Dublin	1
D. Bateson, chairman of the South of England Telephone Company, Limited, 77, West Cornwall-road, S.W.	1
C. Nash, chairman of the Western Counties and South Wales Telephone Company, Limited, Down-square, Bath	1
R. T. Wilkinson, chairman of the Northern District Telephone Company, Rose Dene, Sunderland	1
J. B. Morgan, A.I.C.C., managing director of the United Telephone Company, Limited	1
J. W. Batten, director of the United Telephone Company, Limited, 15, Airlie-gardens, Camden-hill, W.	1
D. Parish, director of the United Telephone Company, Limited, 2, Copthall-buildings, London, E.C.	1
W. Quilter, M.P., director of the United Telephone Company, Limited, 74, South Audley-street, W.	1
F. R. Leyland, director of the United Telephone Company, Limited, 49, Princes-gate, S.W.	1

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	102
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	4
15 Feb.	10/0	Anglo-American	100	$38\frac{1}{4}$
15 Feb.	20/0	— Pref.	100	$64\frac{1}{2}$
12 Feb., 85...	5/0	— Def.	100	13
28 Mar.	3/0	Brazilian Submarine.........	10	$12\frac{1}{2}$
16 Nov.	1/0	Con Telephone & Main ...	1	$\frac{3}{4}$
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	$2/2\frac{1}{2}$	Direct Spanish	9	$4\frac{1}{4}$
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	$8\frac{7}{8}$
12 April	2/6	Eastern	10	$11\frac{3}{4}$
12 April	3/0	— 6% Pref.	10	$14\frac{3}{4}$x
1 Feb.	5%	— 5%, 1899	100	108
28 Oct.	4%	— 4% Deb. Stock	100	$107\frac{1}{8}$
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	$12\frac{13}{16}$
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	$103\frac{3}{4}$
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	$6\frac{1}{8}$x
12 April	2/0	Globe Telegraph Trust......	10	6
12 April	3/0	— 6% Pref.	10	$13\frac{7}{8}$
3 Jan.	5/0	Great Northern...............	10	$14\frac{5}{8}$

Dividend.		Name.	Paid.	Price. Wednesday
1 Mar	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	$17\frac{3}{8}$
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	$5\frac{9}{16}$
16 Mar.	5%	Maxim Weston	1	$\frac{1}{8}$
15 May	5%	Oriental Telephone	11	$\frac{7}{16}$
14 Oct.	4/0	Reuter's	8	$8\frac{1}{4}$
......	...	Swan United	$3\frac{1}{2}$	$2\frac{1}{2}$
15 Feb.	$15\frac{1}{2}$%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	$39\frac{1}{2}$
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	15
......	...	West African	10	5
1 Mar.	5%	— 5% Debs.	100	$92\frac{1}{4}$
29 Dec.........	6/0	West Coast of America ...	10	$5\frac{3}{4}$
31 Dec.	8%	— 8% Debs.	100	117
14 Oct.	3/9	Western and Brazilian......	15	10
14 Oct.	3/9	— Preferred	$7\frac{1}{2}$	$6\frac{5}{8}$
......	...	— Deferred..................	$7\frac{1}{2}$	$3\frac{3}{4}$
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	11
13 May, '80...	...	— 6% 2nd Pref.	10	$6\frac{1}{2}$
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Mar. ...	£37,331	+£1,376
Brazilian Submarine	W. May 4	£4,387	...	Great Northern	M. of Apl. ...	21,400	...
Cuba Submarine	M. of Apl. ...	3,700	+ £736	Submarine	None	Published.	
Direct Spanish.....................	M. of Feb. ...	1,800	+ 119	West Coast of America	M. of Apl. ...	4,325	...
— United States	None	Published.	...	Western and Brazilian	W. May 4	3,649	...
Eastern.............................	M of Apl. ...	51,582	+ 8,446	West India and Panama	F. April 30 ...	3,268	+ 231

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Personal.—Mr. Basil Gee has taken charge of the London sales department for wire and cable of Walter T. Glover & Co., 10, Hatton-garden, E.C., and Salford.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ended May 4 amounted to £4,387.

Eastern Telegraph Company.—The Eastern Telegraph Company's traffic receipts for the month of April, 1888, amounted to £51,582, and to £43,136 in the corresponding period of 1887.

South of England Telephone Company.—The Directors of the South of England Telephone Company, Limited, have declared a dividend of 6 per cent. per annum on the preference shares for the half-year ending April 30.

West Coast of America Telegraph Company.—The traffic receipts of the West Coast of America Telegraph Company for the month of April amounted to £4,325, and those of the Direct Spanish Telegraph Company to £1,800.

Direct Spanish Telegraph Company.—The estimated traffic receipts for the month of April of the Direct Spanish Telegraph Company, Limited, were £1,800, against £1,681 in the corresponding period of last year, showing an increase of £119.

Great Northern Telegraph Company.—The traffic receipts of the Great Northern Telegraph Company for April were £21,400, making a total from January 1 to April 30 of £85,200, against £81,520 and £78,480 for the corresponding months of 1887 and 1886 respectively.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ended May 4, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,649.

Eastern Extension, Australasia, and China Telegraph Company.—The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company, Limited, for the month of April, 1888, amounted to £37,331, and to £35,955 in the corresponding period of 1887, an increase of £1,376.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company, for the half-month ending April 30 were £3,268, against £3,027 for the corresponding period of 1887; the January receipts, estimated at £5,718, realised £5,955.

Consolidated Telephone Construction and Maintenance Company.—The Directors of the Consolidated Telephone Construction and Maintenance Company, Limited, recommend a dividend at the rate of £5. 7s. per cent. per annum for the year ending March 31, inclusive of the interim dividend paid in November last.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Company during April was 4,684, estimated to produce £3,700, against 3,823 messages, producing £2,964, in the corresponding month of last year. The traffic receipts for January, estimated at £3,300, realised £3,366.

Oriental Telephone Company.—At the adjourned meeting of the shareholders of the Oriental Telephone Company, Limited, to be held on Friday, the 25th inst., the proposed dividend of $2\frac{1}{2}$ per cent. free of income-tax, for the past year on the paid-up capital of the Company other than the vendors' shares will be again recommended by the Directors.

Newton's Syndicate.—It is reported that Mr. Newton's New Electric Light Syndicate have entered into arrangements with Colonel J. T. North to dispose of Mr. Newton's patents to a joint stock company with a capital somewhere in the hundred thousands. Electric lighting is about the only branch of industry in which the indefatigable Colonel has not yet embarked.

West India and Panama Telegraph Company.—The report of the Directors of the West India and Panama Telegraph Company, Limited, for the half-year ended December 31, shows an available revenue balance of £21,887, of which £3,000 has been carried to reserve. They propose to pay 10s. per share on account of arrears of dividend on the first preference shares, £1,606 being carried over.

London Platino-Brazilian Telegraph Company.—The report of the Directors for the past financial year states that the net revenue of the year, after providing for debenture interest and income-tax, is £10,925. 12s. 5d., and £1,543. 8s. 8d. is brought in from the preceding year's account, making a total of £12,469. 1s. 1d. to the credit of revenue account. The interim dividend of 2s. 6d. per share, paid on November 22, 1887, absorbed £4,793. 10s., leaving, therefore, to be dealt with £7,675. 11s. 1d., from which the Directors propose to appropriate £150 in further reduction of the item of expenses of issue of the six per cent. debentures, to add £1,000 to the reserve fund, and to apply £5,752. 4s. in payment of a final dividend of 3s. per share, making, with the interim dividend already paid, a distribution at the rate of $2\frac{3}{4}$ per cent. per annum, as against 3 per cent. paid last year, leaving a balance of £773. 7s. 1d. to be carried forward.

NOTES.

Barcelona.—The illumination of the fountains at the Barcelona Exhibition has been placed in the hands of the Anglo-American Brush Company.

Brussels.—The palace of the Comte de Flandre is now lighted by electricity by means of a Lahmeyer dynamo and a set of Julien accumulators.

Erratum.—In the article on "Double and Single or Earth-wire Systems," published last week, the dotted and solid lines in Fig. 1 should be reversed.

Olmutz.—The municipality of this town have resolved to establish an installation of electric lighting in the theatre there prior to the opening for the new season.

Death by Electricity.—The New York Assembly passed the Bill substituting electricity for the halter in the case of criminals sentenced to death, by a majority of eighty-six to eight.

Glasgow Exhibition.—This exhibition was a model of punctuality—not only the machinery and all the electric light being quite ready, but also practically the whole of the private exhibits.

Electrical Watches.—A company has been formed in Berlin to manufacture electrical watches. Two small cells and a small electric motor take the place of the ordinary movement.

Railway Lighting on the Continent. — The electric light is being used for trains on the Wurtemberg railroads, on the Novara-Seregno road in Italy, and on the Russian South-Western line.

Owens' College.—Prof. A. Shuster, Ph.D., F.R.S., has been appointed to the Langworthy Professorship of Physics and directorship of the Physical Laboratory at Owens' College, in succession to the late Prof. Balfour Stewart.

Verona.—The local company formed to establish a central station of electric lighting being unable to carry the project into effect, the shareholders in the gas company have authorised the latter to execute the work in question.

Paris.—It is stated that the Paris Municipal Council intends to request the companies at present distributing electrical power by means of overhead wires to conform to the terms of the conditions of contract now being published in our columns.

Brixton.—We understand that the new road at Brixton, Palmerston-avenue, is to be lighted up by the electric light on the Fyfe main system. These are the sort of items we have to report, as against the continued items of whole towns being lighted in America.

Honolulu.—The town of Honolulu, Hawaii, has been lighted with electric light, supplied by the Thomson-Houston Electric Company, of New York. There are 62 arc lights, and the dynamos are driven by water-power with 300ft. head, 2½ miles from the city.

Society of Telegraph-Engineers.—An extraordinary general meeting of the society will be held on Thursday, 24th inst., when Sir W. Thomson, L.L.D., F.R.S., Past President, will read a paper on his "new Standard and Inspectional Electric Measuring Instruments."

Electric Firearms.—The latest novelty is the employment of electricity instead of percussion caps for firearms. The spark is produced in the same manner as the now well-known gas lighters, and it is claimed that by this means a more powerful explosive than gunpowder can be used.

Brussels Exhibition.—The Brush Company have taken the contract for lighting the British section at the Brussels Exhibition with supply of current for incandescent lamps for exhibitors and restaurateurs. They are also lighting the hippodrome arena with arc lights, and have a 6-light mast at the entrance.

Motor Cars.—After much experimenting with various motors, St. Louis, U.S., has finally adopted electricity as the motive power for their roads, with Julien storage batteries and Brush motors. The contract for the Fourth Avenue, New York, has been taken by the Julien Company, and the price is 40 per cent. below that of horses.

New Technical Schools.—Blackburn is going to spend £25,000 on building a technical school of most approved construction. Mr. E. C. Robins, F.S.A., the well-known expert in technical colleges, had the selection of the design, which was won by Messrs. Smith, Woodhouse, and Willoughby, 100, King-street, Manchester.

Eastbourne.—A memorial was received last Monday by the Eastbourne Town Council from the inhabitants of the Royal Parade, calling attention "to the great existing want of the electric light on the Royal Arcade." At present the gas lamps are not in keeping with the electric lights on the Grand Parade. The matter was referred to the Lighting Committee.

True Burglar Alarm.—Instead of a small bell placed near the bed to wake the occupier, by far the better way, it is suggested, will be to connect the doors and windows with a good 18in. gong in the hall; then, instead of the master of the house having to come down to persuade the burglar to go, the burglar departs of his own free will—for what burglar would stay to burgle with an 18in. gong going?

Electrical Tramway for Leamington.—An experiment is about to be made at Leamington in electrical tram-cars. The Milverton Local Board have given their sanction to the project, and its introduction is looked forward to with exceptional interest. It is believed that the intention of the promoters is to utilise the electricity generated during the day in connection with the Midland Electric Lighting Company.

Royal Society.—The following papers were read at the Royal Society on Thursday, May 17:—Prof. J. Burdon Sanderson, F.R.S., "On the Electromotive Properties of the Leaf of Dionæa in the Excited and Unexcited States, No. II."; Prof. Ewing, F.R.S., and G. C. Cowan, "Magnetic Qualities of Nickel"; Prof. J. C. Ewart, "On the Structure of the Electric Organ of Rala circularis."

New Siemens and Halske Dynamo.—In a new type of dynamo machine constructed by this firm, the field-magnet, of four branches, is placed within the circumference of a Paccinotti ring, the magnet being stationary, and the ring revolving about it. One of the experimental machines on this type, weighing less than 13cwt., and running at 350 revolutions per minute, gave a power of 16,000 useful watts, whilst at 480 revolutions the power rose to 25,000 watts.

A New Lamp Factory.—A new manufactory for incandescent lamps has been started at Stockholm, Mr.

R. W. Strehlenert having removed to this town from Sodertelge, where for a couple of years he has been engaged in connection with this manufacture. Mr. Strehlenert has succeeded in securing an able staff of men, and is at present turning out some 600 or 700 lamps a week, which number, however, can be raised to 2,000 a week if required.

Hastings.—We are glad to note that the Hastings Electric Light Company's report, just issued, shows that the directors will be able, at the sixth annual meeting of shareholders on the 22nd inst., to recommend a dividend of 3 per cent. The tide at last has apparently turned with this pioneer company. Most of the principal hotels are now using the light, and many further applications are being made, and we may evidently look for continued progress and success.

Bicycle Papers Please Copy.—The bicycle manufacturers in America are introducing the process of electric welding by the Thomson-Houston process into their works. A delegation of makers recently made a visit to the Thomson-Houston factory and witnessed trials of the process, which were very successful. We believe that the whole process of Thomson-Houston welding is in the hands of the well-known electrical engineers, Laing, Wharton and Down, in this country.

Relative Cost of Electric Light.—The following significant figures are taken from a report sent to the Corporation of Chicago by Prof. Barret. They compare the annual price of maintenance of the electric light with that of gas, taking into consideration all expenses, fuel, interest, depreciation, and repairs, &c. Gas: 3,273 burners, 52,368 candle-power, £13,053. Incandescent lamps: 3,273 lamps, 98,190 candle-power, £8,900. Arc lamps: 750 lamps, 1,500,000 candle-power, £7,475.

Tempering Magnets.—A combined process for tempering and magnetising steel bars for magnets is employed by M. Ducretet. He employs a water-tight vessel, at the bottom of which are two soft iron pole pieces; the poles of a powerful electro-magnet are placed underneath these. The vessel is partly filled with water, and a layer of oil is above this. The red-hot bar is passed through these; its passage first through the oil is found to soften the steel without depriving it of its power of being magnetised.

Testing Water.—It has long been known that if a voltmeter is filled with perfectly pure distilled water it is impossible to pass an electric current through it. If, however, a few drops of acid, or a small quantity of soluble salt, is dissolved in the water, the current passes and electrolysis takes place. Dr. Carpené has proposed to make use of this fact to determine the quantity of a given impurity contained in water, as experiment shows that at a given temperature a definite quantity of any substance must be dissolved in the water before the current will pass.

The Advantage of Electric Trams.—Colonel Henry Flad, one of the foremost engineers of America, at present head of the St. Louis Board of Public Improvements, recommends the use of electric rather than cable tram-roads, except for very steep gradients. The chief advantage in his eyes is that each storage car is an independent unit. "The importance of this, particularly in large cities and with long lines, cannot be over-estimated; and I would recommend the electric motor, with storage batteries, even if a cable road could be constructed and operated at *less expense*."

The Paris Exhibition.—We have much pleasure in stating that Mr. John Aylmer, of Paris, has been appointed by the Executive Council of the Lord Mayor's Committee for carrying out the English Section of the Paris Universal Exhibition of 1889 as their hon. secretary in Paris. The success which attended Mr. Aylmer's management of the Paris Electrical Exhibition of 1881 (where he acted as secretary to the English Commission) will no doubt be repeated next year in the larger undertaking, and we congratulate the executive in having secured the services of such an able and zealous official.

A New Insulating Compound.—A very valuable insulating material, described in the *Chronique Industrielle*, has just been produced. It is composed of one part Greek pitch and two parts burnt plaster, by weight, the latter being pure gypsum, raised to a high temperature, and plunged in water. This mixture, when hot, is a homogeneous, viscous paste, and can be applied with a brush, or cast in moulds. It is amber-coloured, and possesses the insulating properties of ebonite, and can be turned and polished. Its advantage is its endurance of great heat and moisture without injuring its insulating properties.

Bradford.—The Corporation at Bradford have unexpectedly encountered an obstacle in their lighting scheme. They thought only to ask and have the necessary sanction from the Local Government Board for borrowing the money; but it is found that a local inquiry must be held, and the whole affair is to be fully considered at Whitehall. Moreover, the tenders are so numerous and various as to give rise to the suggestion that the specification was too vague, and it has been alleged that economy was not kept in view—among other things, that an odd gauge of wire for the cables was specified, which is not kept in stock by manufacturers, and would have to be drawn specially. Meanwhile the whole thing hangs fire.

Herr Hempel's Micro-Telephone Station.—Herr Alwin Hempel, of Dresden, has invented a micro-telephone station, in which the microphone is so extremely sensitive that it reproduces the most softly whispered tones. The reproduction of the spoken voice is so exceptionally loud that even deaf people can avail themselves of Herr Hempel's apparatus, which can, moreover, be employed for the transmission of music. More than 100 telephones can be connected with a single one of these microphones. Herr Alwin Hempel is in possession of a testimonial from Prof. Dr. Kohlrausch, one of the first authorities upon electro-technical matters in Europe, who states that he knows of no microphone station which works better than that patented by Herr Hempel.

Licenses to Electric Light Men.—In Boston, U.S., an electrical exchange has been established to issue licenses to men engaged in electric light work. It is expected that the institution, properly conducted, will prove of great advantage to both men and companies. The licenses are divided into five classes. First class, to instal and operate any electric light and power plant; second class, to instal and operate any two of the following—viz., incandescent, arc lights, or power; third class, to instal and operate any one of the above; fourth class, to operate electric machinery, but not to instal; fifth class, to do electric wiring, but not to operate electric machinery. The New England underwriters have expressed their willingness to co-operate with the electric light men in licensing employés.

Lightning Express.—"Electric Expressage," invented by David G. Weems, of Baltimore, is one of the latest developments in rapid transit schemes, and by means of which newspapers, mail matter, and express packages will reach Chicago from New York in about two hours, and in seven hours more the "matter" would reach San Francisco, Cal. This car will travel at the rate of nearly four hundred miles an hour on a light elevated railway, and will run automatically, just the same as some of the cash-carriage contrivances used in large stores; and the system is in some respects similar to the Adams' elevated railway, only on a much smaller scale. The Electric Automatic Transit Company has been organised to build a test line in Washington at once, and a line is to be constructed in Maryland in a few months.—*Chicago Street Railway Gazette.*

Voltmeters and Ammeters by Repulsion.—The volt- and ammeters made by the Waterhouse Electric and Manufacturing Company are constructed on the principle of electro-magnetic repulsion, which is a constant with equal current. Heretofore such instruments have been made to act by means of a permanent magnet, or in their construction a coil spring has been used, so that the magnetism of the magnet, or the resilience of the spring has been a varying quantity, and frequent calibration has been necessary to correct these variations. The Waterhouse instruments are calibrated by the Cornell University standard, and once adjusted remain in adjustment. An ammeter may be left in the circuit with the current continually passing through it, but its adjustment is unchanged. The instruments are very sensitive to variations of the current transmitted through them, and are not only adapted to electric light stations, but also for the finest laboratory tests. The company also make a very fine galvanometer and other delicate instruments.

Extension of Motors.—"The day is not far distant," says Mr. Franklin Leonard Pope, in an interesting and valuable paper in a recent number of *Scribner's Magazine*, "when rapid transit between the principal cities of America will be effected to an extent which to persons unfamiliar with the developments of electricity must seem utterly visionary and chimerical. Once admit, as we must do, the possibility of applying almost limitless electric power to each axle of a train, with the possibility of laying a track almost as straight as the crow flies from city to city, rising and falling as the topography of the country may require, and the complete solution of the problem becomes little more than a matter of detail. Not that such detail is unimportant, nor that the innumerable minor difficulties can be overcome without much experiment and study; but it may, nevertheless, safely be affirmed that the ultimate result is already distinctly foreshadowed, and that we may expect within a few years to be transported between New York and Boston in less than two hours, not by the enchanted carpet of the 'Arabian Nights,' but by the potent agency of the modern electric motor."

Cloud Telegraphy.—A remarkable experiment in signalling with electric lights was recently made by the officers of two vessels of the British Navy, the Orion and the Espoir, off the port of Singapore. The Espoir had sailed from that port for Hong Kong, leaving the Orion in the harbour of Singapore. When the Espoir was sixty miles distant, the Orion sent her a message by throwing a brilliant light upon the clouds, and the reflection of this was seen distinctly by those on board the Espoir, and by this means a regular message of alternate long and short flashes was read and understood by the Espoir. The practical use of cloud telegraphy as a recognised means of communication would probably be confined to special circumstances, and would, of course, depend upon the state of the weather, but the possibility of communicating a distance of 60 miles at night without wire is very important. The first application of such a means of telegraphing which suggests itself is that of lighthouses, whose lights could be rendered visible to a much greater distance on cloudy nights if provided with an apparatus for flashing on the clouds. The reflections often seen at night from the blast furnaces in some of the large manufacturing towns are visible to a great distance, and give some idea of the effect of the electric light upon the clouds.

Incandescence Lamps v. Fire Risks.—The results obtained in the experiments with incandescence lamps recently made by M. Mascart point to the necessity in certain cases of increasing the size of the glass containing vessels, so as to increase the area through which heat may be dissipated by conduction. Lamps of 12 or 16 c.p. would no doubt be perfectly safe; but two of M. Mascart's 32-c.p. lamps carbonised the wadding with which they were surrounded, and, ultimately bursting, set fire to the charred material. A third lamp of the same c.p. destroyed the double thickness of cotton fabric in which it was enveloped, but without setting fire to it. Silk was destroyed in the same way, and commenced slowly to burn. A similar lamp produced no effect in 20 minutes when placed in a fold of old scene-canvas; but with a lamp of 300 c.p. the material was charred, and commenced to burn, without flame, in one and a half minutes. We should be interested to know the size of the last-mentioned lamp. We have seen a 100-c.p. incandescence lamp within a glass vessel but little larger than that surrounding an ordinary 16-c.p. filament. One of these has been known to completely char the wood of its holder, and actually melt the glass of its own bulb; and it is probable that M. Mascart's 300-c.p. lamp was constructed without any precaution to provide for the dissipation of the comparatively large quantity of heat generated in a given time.

The "Telegraphist."—After a struggle of four years the *Telegraphist* has ceased to exist. It is as characteristic of the Englishman not to support his professional paper as it is with the Americans to do the opposite. We presume that although the editor in his "farewell" speaks of a support of 50 per cent., if he had received the support of half that number it would have satisfied him, and carried him and his paper on to success. The great branch of applied electricity—hand telegraphy—is now unrepresented, unless, indeed, our contemporary the *Telegraph Journal* sees fit to devote more attention to the subject indicated under its older title; but we doubt if such will be the case, as its proprietors long since found—and as Mr. Lynd has more recently found—support will not be forthcoming from those who are most directly connected with telegraphy. We admire the pluck with which Mr. Lynd has stuck to his task, and regret such determination has had no better ending. Of course, one great deterrent to the success of such a paper exists in the fact that telegraphy being under Government control, there is no great incentive for advertisers to advertise—at least, that is how they look at it. On the other hand, those more or less behind the scenes know that the conclusion is absolutely incorrect; besides, it should be noted that every railway deals largely

with telegraphic apparatus. But this business runs somewhat in a groove; a firm gets the orders of a particular railway and looks upon that success as sufficient, troubling no further, so year after year the orders go in the same directions, and all men connected therewith are pleased.

Wimshurst Machines.—At the Royal Institution, London, lately, Mr. James Wimshurst delivered a lecture on electrical machines. The audience was large, because Mr. Wimshurst's name is known wherever electrical machines are used, and it was known that there would be something magnificent to see. The lecturer passed briefly over the history of the subject, but showed a working model of the parent of all the modern machines, which was invented by Nicholson one hundred years ago. He said but little about the theory of machines; indeed, he seemed rather sceptical when he spoke of theory at all, an attitude which he may be excused for taking, for he quoted at length a statement made by Sir William Thomson when the Holtz machine was invented, according to which that machine was successful beyond all expectation, because Holtz had discarded metallic carriers and contact brushes. Now, the lecturer, not knowing the views of this distinguished physicist, did those very things which, according to this authority, he should not have done, with the result that he produced a machine far in advance of the Holtz in every way. He said that had he known what Sir William had written he would never have ventured in the direction he did, and the Wimshurst machine might never have been made. At the conclusion of the lecture he justified his eulogy of the machine which bears his name by treating the audience to a display of artificial thunder and lighting such as few, if any, of the audience had seen before. Indeed, had such machines existed before the time of Franklin, there would have been but little occasion to send up that historic kite, which proved that the puny sparks at that time obtainable were truly the same in kind as the lightning-flash.

Electrical Bullet Probe.—At a recent meeting of the New York Academy of Medicine, Dr. Girdner, of New York, exhibited his telephonic bullet probe. The following account of this apparatus, which we must confess is in great measure unintelligible to us, appears in some of the New York papers:—"The interesting feature of this probe is that it is operated by a current of electricity extracted from the body of the patient himself in whom it is desired to locate a metallic missile." (We suppose this means that the body of the patient constitutes the electrolyte of a voltaic couple, constituted by the probe and the "hollow bulbous piece of steel" mentioned below; although no intimation is given that one of these is electro-positive to the other.) "The construction of this probe is as follows: To each of the two terminals of a telephone receiver an insulated flexible wire about 4ft. long is connected. At the free end of one of these wires a hollow bulbous piece of steel is attached. At the free end of the other wire is a suitable handle, in which a probe may be placed, and held by a clamp screw. The internal arrangement of the handle is such that a perfect electrical contact exists between the end of the probe and that of the wire which terminates in the handle; the same is true for the end of the other wire and the steel bulb." (This, one would think, "goes without saying.") "When a current of electricity is passed through the coil in the receiver by means of the bulb and the probe, each time that the current is made and broken *a clicking or rasping* sound is heard in the receiver held to the ear. All sounds are shut out except that heard when the bullet is touched [how about the clicking or rasping sound just mentioned?]; and the apparatus is so constructed that both hands are left free."

Gas v. Electricity.—The *Bulletin International de l'Electricité* gives a possibly useful word of warning to those who might be inclined to understate the cost of lighting by electricity as compared with that of gas lighting. When extensive works, hotels, or shops have to be lighted, and it is practicable to install gas or steam engines and a dynamo machine on the premises, electricity, as in many cases has been proved, offers a real economy over gas. But it must be borne in mind that in these cases it is the *cost* price of the electrical power which is compared with the *selling* price of gas, which includes the profit of the gas company, besides the general expenses of production. This accounts for the fact that the economical advantage of electricity disappears, or at least is no longer so appreciable, when the supply takes place from a central station. We have, then, the selling price of electrical power compared with the selling price of gas. On the other hand, it is to be considered that improvement is naturally and continuously being effected in the production and in the supply of electrical power, and that theory, which is altogether on the side of electric lighting, is gradually being approximated to in practice. Theory clearly indicates that more light is to be obtained from a ton of coal by utilising it for the production of electrical energy than by employing it for the production of gas, due allowance being made for the value of the residual coke. Thus, a ton of coal utilised in good steam engines corresponds to 600 h.p. hours, and, consequently, to 5,000 lamp hours, of 16 candles, or 8,500 carcels. A ton of gas coal gives 300 cubic metres of gas, and 600 kilos of available coke; the former can produce 2,857 carcels, and the latter, consumed in the steam engine, 2,600 lamp hours of 16 candles, or 4,420 carcels. Thus, *a priori*, electricity has a luminous efficiency superior to that of gas of 1,200 carcels per ton of coal, or superior by 16 per cent. on a liberal theoretical estimate.

Telephoning to Trains in Motion.—M. Germain read a paper on April 23, before the Sociétés Savantes, Paris, describing a new system of telephonic communication between trains in motion and neighbouring signal-boxes. In considering the application of electricity to the lines of railroads, M. Germain pointed out that, by reason of their *resistance* and *insulation*, the two lines of the same railway, connected together, constitute an excellent conductor when they are *part of a circuit not communicating to earth*, and when the battery is also well insulated from earth. He states that a new line has less resistance than an old line because of the oxidation of the fish-plates, and of the alteration of the molecules of steel due to vibrations. Suppose a circuit constituted between two stations, 1st, by a wire suspended on posts, 2nd, by the rails coupled electrically. If a battery is inserted at one of the stations, and if a telephone is inserted on the train at a point in the circuit formed by the two last wheels of the guard's van, the guard plate, and the draw-bars of all the carriages, the telephone will reproduce telegraphic signals given at the fixed station. The train may be running at its greatest speed, the signals are equally distinct. The telephone thus connected is in a secondary circuit, moving along the rails. The potential in both circuits is the same. The production of spoken words by two receiving telephones, one on the train and one at the station, is very feeble; but if the current of the battery is trans-

formed by means of an induction coil into a high-tension current, and a microphone of twelve carbons is inserted in the inducing circuit, words are then reproduced with remarkable clearness. By the simple device of a moving secondary circuit formed by the metal connections of the train, with the aid of a single wire placed below the ordinary telegraph wires, telephonic communication can be obtained with trains in motion. For trains in motion to communicate with the stations, two currents of equal intensity are set in opposition, one in the primary, the other in the secondary circuit. When the currents are equal, the telephone is silent; by interrupting the current in the moving secondary circuit, signals can be heard in the telephone. With similar apparatus to that at the station, in each guard's van, ordinary telephone communication can be established both ways. The telephone will not produce words clearly until a potential of 450 volts are attained—the quantity is about two to three milli-amperes. A battery of twenty cells, weighing altogether 132lb., giving normally 1·5 volts and six amperes per cell, is required for each station and for each train.

Long Distance Telegraphy.—The recently announced claim, says the *Scientific American*, of a telegraphic circuit of over 6,000 miles, surpassing all previous experiments, is somewhat misleading. Many efforts at long circuit work have occurred during the past few years, the distance varying from 4,600 to 8,100 miles. It is a matter of considerable pride to the old operators of the Western Union Telegraph Company in San Francisco, says the San Francisco *Alta*, that the feat of transmitting clock signals through 7,200 miles of line and communicating directly through that same line has never been equalled. The occasion of this feat was the telegraphic determination of the difference of longitude in time between the United States coast survey station in San Francisco and the observatory of the Harvard University at Cambridge, in the year 1869. In order to determine the time of transmission of a signal either from the clock or from the operator's key over the given length of the line of 3,600 miles, three different methods were devised. One of these was original with Prof. George Davidson, who had charge of the observations. Through the liberality of the management of the Western Union Telegraph Company, a double circuit of line was looped at Cambridge, so that there extended from the San Francisco observatory 3,600 miles to Cambridge, and the return from Cambridge by a somewhat different route of nearly equal length. The two "earths" were under the San Francisco observatory, distant from each other not more than 10ft. The line was first opened by an operator in the observatory, and when the fast connection was made at Cambridge, the San Francisco operator was considerably astonished to get his own message back within one second of time. Then the astronomical break circuit clock was thrown into line, and made its first break on a pen recording upon a revolving cylinder of paper in the San Francisco observatory, and after this break had traversed the line to Cambridge, it returned and made a break upon a second pen moving parallel with the former, in about eight-tenths of a second of time. This was continued every second for several minutes, and was repeated upon several nights, and when one of the twelve batteries in this long circuit was removed the wave length time was reduced to only sixty-five hundredths of a second. Communication was, of course, carried on at the same rate of speed. This feat over a line 7,200 miles in length has been unrivalled up to the present time, both as a practical working exhibit and a scientific success.

Windmills v. Electricity.—The question is one of almost universal interest, why windmills are not more often employed for generating electricity in conjunction with accumulators for storing the energy thus produced. Windmills are not used to such an extent in England as they are in America, but even there windmill generators do not seem to make much progress. Mr. A. R. Woolf, M.E., author of "The Windmill as a Prime Mover," New York, has written a valuable note upon the question of windmills in the *Steven's Indicator*, in which he says that first credit was due to Sir W. Thomson for suggesting the use of windmills at the meeting of the B.A., 1881, though he expressed doubts as to its utility on account of the comparative cost. Mr. Wolff holds that Sir W. Thomson's reasoning was not quite correct, and that when the only correct basis of comparison of the economy of different prime movers is instituted—viz., the cost of obtaining the horse-power developed per unit of time, such cost consisting of the sum of interest, repairs, and depreciation of plant, cost of fuel, oil, and attendance, and similar items of expense entering the power account—the windmill is the most economical motor for the development of power in moderate and small quantities. The non-employment of windmills is not owing to the often alleged fact that the rate of revolution of the windmill, according to the varying force of wind, is too irregular to run a dynamo for the purpose of charging a storage battery, or that the wind cannot be depended on for a sufficient length of time per day. The real facts of the case are that in the leading American windmills—as is attested by hundred thousands in daily use in pumping practice—governing appliances of various kinds, of approved design and experience, automatically so vary the extent of surface presented to the wind, that a practically uniform rate of revolution is obtained, irrespective of direction and varying velocities of wind, for all winds exceeding a velocity of six miles per hour. This latter velocity must be reached before windmills of good design, as ordinarily constructed, operate at the rate of revolution for which they are set. It has been found by experience that, on an average, for at least eight hours out of the twenty-four hours of each day, the wind exceeds this velocity of six miles per hour, the average velocity of wind, during the eight hours of run, being 16 miles per hour. Total calms in excess of two days' duration are practically unknown in the United States. The fact that the windmill is at rest, often at short intervals, aggregating not quite sixteen hours out of the twenty-four, is no objection to the use of this motor for the purposes of driving dynamo machines to charge electrical accumulators, for one of the very features and acknowledged requisites of such accumulators should be that they can be charged spasmodically, at will, and at odd times. The result of study of this question must be that the reason windmills are not used in this way, is not that the windmills are not sufficiently economical or reliable, but that the electrical accumulators are not yet a satisfactory and assured success. When they are, windmills will come into extended use as prime movers for the generation of electricity, and electricians will be glad to avail themselves of the most economical motor, utilising the force of wind, otherwise going to waste, for this purpose. The windmill at the present day is in a developed state, a practical success, ready and available for this new use at once. It awaits the electrical accumulator that is a success.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 415.*)

TESTS OF LOW RESISTANCE.

Thomson's Secondary Conductor Method.—An excellent method of testing low resistances was proposed about thirty years ago by Sir William Thomson. The arrangement is illustrated diagrammatically in Fig. 20, and a convenient apparatus for carrying out the test practically is illustrated in Fig. 21. From Fig. 20, it will be seen that the arrangement is similar to the ordinary Wheatstone's bridge. The rod, w, to be tested is placed in series with a standard rod, w_1, and a current is sent through them from the battery, B. The ends of two shunt circuits, containing known resistances, are placed in contact with the rods at the points 1 and 4 and the points 2 and 3, and a galvanometer is joined from 5 to 6. The resistances of these shunt circuits must be so large that the resistance of the contacts at the rods will not produce a sensible percentage change in their value—that is to say, they should be at least a few ohms each. The theory of the method may be stated as follows: Let the difference of potential between the joints 1 and 2, 2 and 5, 5 and 3, &c., be a, b, c, &c. Then we have, when no current flows through the galvanometer, G, the sum of the differences a and b equal to the difference between 1 and 6, or f, and similarly the sum of the differences c and d equal to e. Hence we have

$$a+b=f,$$

and

$$c+d=e.$$

$$\therefore \quad \frac{a+b}{c+d}=\frac{f}{e}.$$

Suppose, now, that $\frac{b}{c}$ is made equal to $\frac{f}{e}$, and we will have

$$\frac{a+b}{c+d}=\frac{b}{c}=\frac{f}{e},$$

and $\therefore$

$$\frac{a}{d}=\frac{b}{c}=\frac{f}{e} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Since no current flows through G it is clear that the same current flows from 1 to 6 as flows from 6 to 4, and for the same reason the same current flows through w and w_1. Hence, if r and r_1 be the resistance from 1 to 2 and from 3 to 4 respectively, and R and R_1 the resistance from 1 to 6 and from 6 to 4 respectively, we have by Ohm's law and equation (1)—

$$\frac{a}{d}=\frac{r}{r_1} \text{ and } \frac{f}{e}=\frac{R}{R_1},$$

and therefore

$$\frac{r}{r_1}=\frac{R}{R_1} \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Equation (2) shows that the resistance between the points 2 and 3 does not enter into the result explicitly; but it must be remembered that one of the conditions of the solution was that b/c should be equal to f/e, and hence, for absolute accuracy, this condition must be fulfilled. If, however, the sum of the resistances of the parts of the main conductor and the contact at C is small compared with r or r_1, the difference of potential between 2 and 3 will be small compared with the difference between 1 and 2 or between 3 and 4, and hence a considerable deviation from the proper value of b/c would not introduce much error. It is clear, therefore, that if care be taken to keep the resistance of the primary conductor between 2 and 3 small, the resistance of the secondary conductor between these two points may be made moderately small also, without introducing any serious error due to the resistance of the contacts at 2 and 3. The resistance of the secondary circuit between 1 and 4, however, must always be great compared with the resistance of the contacts at these points. This method possesses considerable advantages in point of sensibility and simplicity. It requires only one galvanometer, and since the method is a zero one any sensitive galvanoscope will do. The resistances of the secondary conductors may be fixed and unvariable if the points of contact, 1 and 4, can be varied, and therefore the chances of accidental error are small. A convenient form of apparatus for making tests by this method is illustrated in Fig. 21. Referring to this figure, P is a heavy sole plate, on which a vertical board is mounted which supports a double-scale rod, D, and two metallic slide rods, A. On the sole plate, and in front of the vertical board, there is fixed a copper block containing two mercury cups, m, m, one at each side of the scale rod. This block serves to connect the standard rod, C, and the rod to be tested, C_1, and corresponds to the connecting

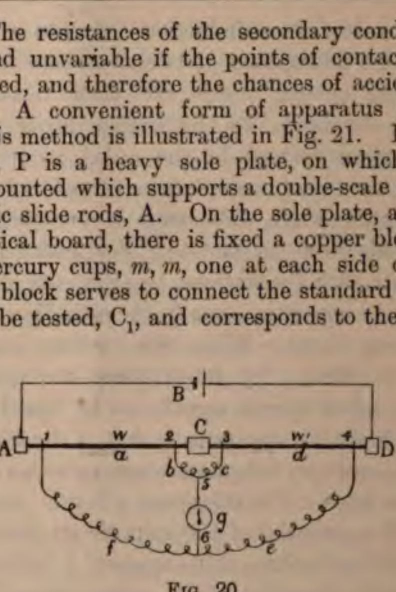


FIG. 20.

piece, C, in Fig. 20. The tops of the rods, C and C_1, are fixed in binding screws, t, t, corresponding to the blocks, A and D, in Fig. 20. To the blocks, t, t, the terminals of the battery circuit are to be connected through a reversing key arrangement, as shown. The battery, B, should be capable of producing a considerable current without much polarisation, and the strength of the current should be regulated by resistance placed

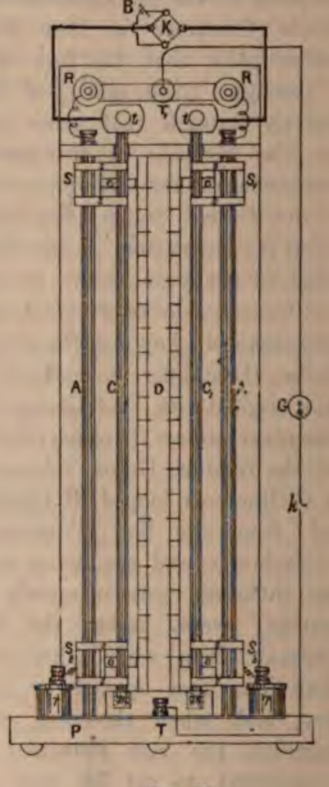


FIG. 21.

in its circuit. The reversing key, K, and the galvanometer key, k, may be arranged side by side, and an ordinary lever reversing key used for K, so that the battery and galvanometer circuits may be easily and quickly made and broken during the tests. On the sole plate, P, two resistances, r, r, are fixed, and one end of each of these is attached to a metal strap which carries the terminal, T. These resistances give, when connected to the bottom sliders, S_2, S_3, the secondary circuit, 2, 5, 3, in Fig. 20. A similar pair of resistances, R, R, are fixed at the top of the vertical board, and when one end of each is attached to a metal strap carrying the terminal T_1 and the other ends to the upper sliders, S S_1, they give the secondary circuit, 1, 6, 4, of Fig. 20. The sliders S_2 S_3 consist of a contact piece, c, bevelled

so as to touch the rods, C or C_1, at one edge only, and held against the rod by two springs, *s s*, which carry insulating pieces on their ends to prevent them touching the rods. The lower sliders are insulated from the slide rods, and the contact tongues, *c*, are connected directly to the resistances *r*. The upper sliders are in metallic contact with the slide rods, and the resistances R are connected to them through the slide rods, which are provided with terminals at their upper ends. The slide rods are, of course, so thick that any difference of position of the slider makes no sensible difference in the value of R. The resistances R R and *r r* are here shown on separate bobbins, but there is some advantage both in cheapness and in efficiency when each pair of them are wound on the same bobbin. The chief advantage in efficiency lies in the fact that the coils, being close together on the same bobbin, their temperatures are always very nearly the same, while the terminals are so close together that there is little chance of much thermo-electric disturbance due to difference of temperature at the connections.

To put the test rods in this apparatus, the sliders are turned round in the slide rods as axis, and the test rod placed between the springs, *s*, and the contact piece, *c*. The upper end of the rod is then passed through the terminal *t* until the rod can be turned into position and inserted into the mercury cup, *m*. The lower contact piece, *c*, is then set so that its upper edge is in line with the lowest division of the scale, D. The upper slider on the rod, C or C_1, which has the lowest resistance, is then placed so that the lower edge of *c* is in line with the highest line on the scale, D, and the slider on the other rod moved until no deflection is produced on the galvanometer G when the battery and galvanometer circuits are closed. The proper position for both directions of the current is found and the mean reading taken. When the two resistances R are equal to each other, and also the two resistances *r* equal to each other, the resistance per unit length of the rod under test, C_1, is to the resistance per unit length of the standard rod, C, in the same ratio as the reading of the top slider on C_1 is to the reading of the top slider on C.

This apparatus is, in the form here shown, most suitable for the measurement of the resistance of a straight rod, and hence its chief use is for the determination of the specific resistance of specimens of thick conductors It may be readily used, however, for measurement of the resistance of any wire or coil, provided suitable standard rods, C, are available. The wire or coil is substituted for the rod C_1, and, if it consists of flexible wire, it should be provided with stiff terminal pieces for insertion into the sliders S_1 and S_3; the lower terminal piece making contact also with the mercury, cup *m*. The resistance is then determined by finding the length of the standard rod to which it is equivalent. It is, of course, possible, by using boxes of resistances instead of the fixed resistances *r r* and R R, to measure the resistance of a coil, although it is considerably greater than that of the standard, by using the proper ratios in the bridge; but it is better to adhere to equal ratios, and provide a sufficient number of standard rods to allow any resistance up to about a tenth of an ohm to be measured. Several other methods of measuring low resistances have been proposed, and some of them, notably a method used by Matthiessen and Hockin in their experiments for the British Association Committee on electrical standards, have been extensively used. The methods here described will, however, be found to be simple, readily applied, and, for almost all purposes, sufficient.

Specific Resistance.—The specific resistance of a conductor is the resistance between the ends of the unit length of a specimen of the conductor, the cross section of which is unity. This is clearly equivalent to the resistance of any length of the actual conductor, divided by the length, and multiplied by its cross section. The cross section of the conductor is here supposed to be uniform, or so nearly so that the mean cross section may, without sensible error, be used in the calculation. This is the case with all ordinary wires and rods used in electrical installations. The experimental determination of the specific resistance, *s*, of any conductor consists therefore in finding, by one or other of the methods above indicated, the resistance, R, of a certain length, *l*, say a metre of it; measuring the cross section, *a*, and then calculating the value from the equation

$$s = \mathrm{R}\frac{l}{a}.$$

The cross section can generally be determined, especially in the case of thick cylindrical specimens, with sufficient accuracy by direct measurement of the diameter with a micrometer gauge. The diameter should be measured at several points along its length, and also across several diameters for each section. Unless the diameters differ considerably from each other, the mean diameter *d* may be taken, and the section calculated as

$$a = \frac{\pi d^2}{4}$$

or, in this case, $$s = \frac{4\,\mathrm{R}\,l}{\pi d^2} = \frac{4\,\mathrm{R}\,l}{3{\cdot}1416\,d^2}.$$

When great accuracy is required, or when the section is irregular, the cross-section may be very accurately determined by weighing either the whole specimen, or, if that cannot be readily done, several parts of it, both in air and in water, and calculating the volume from the difference between the two weights. For this purpose it is convenient to take the dimensions in centimetres and the weight in grammes, because, since the weight of a cubic centimetre of water at 4deg.C. is one gramme, the difference of the weights in grammes gives the volume of water displaced by the specimen—that is to say, the volume of the specimen in cubic centimetres. Thus, let the weight of the specimen in air be w grammes, and the weight in water w_1 grammes. Then its volume, v, is equal to $w - w_1$ in cubic centimetres, v, w, and w_1 being here treated as simple numbers without reference to the nature of the quantities represented. There are some small corrections required in the simple formula here given when great accuracy is required. In the first place, the weight in air is only accurate when the volume of the body weighed is the same as the volume of the weights used in weighing it, and, again, the density of water changes somewhat rapidly with temperature. Most of the conductors ordinarily used when weighed with brass weights require no sensible correction, for the weight in air and the correction for expansion of water with temperature may be taken as 0·027 per cent. when the water is at 10 deg. C. and 0·10 per cent. when it is at 16 deg. C. Care must be taken, when making the weighing in water, that no air bubbles adhere to the sides of the specimen. This may be very perfectly avoided by putting the specimen in boiling water and allowing it and the water to cool together before weighing, but generally if the specimen be carefully wetted, and weighed at once, almost exactly the true volume will be obtained. The specimen should be weighed in air both before and after it is weighed in the water when it is put in boiling water and allowed to remain in it until the water cools, because in this case it is likely to gain in weight by oxidation. If it is carefully dried—first in blotting paper, and then in a current of dry air—so as to avoid oxidation after removal from the water, the weight after removal should be used in the calculation. There should not, however, be such a difference between the weighings as to make any sensible difference in the section of the conductor.

If l_1 be the length of the specimen weighed, w and w_1 the weights in air and water respectively, then

$$a = \frac{w - w_1}{l} \text{ and } s = \frac{\mathrm{R}\,l\,l_1}{w - w_1}.$$

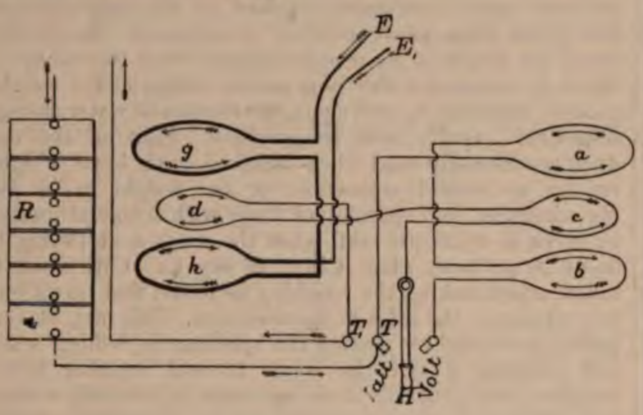
With regard to the magnitude of the specimens required for a satisfactory determination of the specific resistance of the material, it may be remarked that a length between the contacts 3 and 4 of Fig. 20, or the corresponding contacts in the other methods, equal to one or more times as many lineal centimetres as there are square centimetres in the cross section, may be measured when proper appliances are available. Care should be taken, however, that the contacts are not made so near the end of the rod that the current is not uniformly distributed across the section A length equal to two or three times the diameter should always be left between the ends of the rod and the points of contact of the shunt-circuit.

(To be continued.)

ON A NEW COMPOSITE ELECTRIC BALANCE.*

BY SIR WILLIAM THOMSON, F.R.S.

This instrument has been designed for the purpose of providing in one instrument the means of measuring (*a*) the difference of potential between two points of an electric circuit—as, for instance, the difference of potential between the supply conductors of an electric light installation, (*b*) the current flowing in such a circuit, and (*c*) the rate of working in the circuit. The instrument thus forms a combined voltmeter, ampere-meter, and watt-meter. The general form of the instrument is similar to that of the standard centi-ampere or deci-ampere current balances, and it consists of (1) two coils of silk-covered copper wire fixed one above the other, with their planes horizontal, on a slab of slate; (2), two coils of similar wire made up in the form of anchor rings, and fixed to the ends of a balance beam; (3), two coils fixed similarly to (1), but capable of carrying currents up to 500 amperes. The beam of the balance is suspended by two flat ligaments of fine copper wire in such a position that one of the coils fixed to the ends of the beam is suspended midway between the fixed pair of fine wire coils (1), while the other suspended coil is similarly placed relatively to the thick wire, or current coils. When the instrument is used for the measurement of alternating currents, the strong-current coils are made by two or three turns of a stranded conductor. Each wire of the stranded conductor is covered with silk so as to insulate it from the others, and in order, as far as possible, to annul the effect of induction in causing the current to be different at different distances from the axis of the conductor, the strand is given one turn of twist for each turn round the coil.



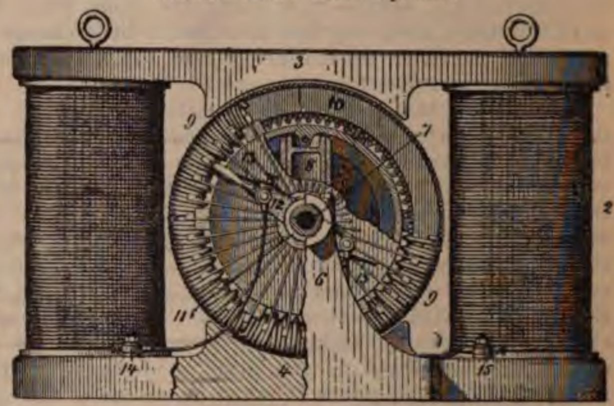
The arrangement of the connections in the instrument will be readily understood from the figure, which shows diagrammatically the arrangement of the coils. In this figure, *a* and *b* represent the fixed fine wire coils, *c* and *d* the suspended coils, and *g* and *h* the strong-current coils. The instrument is joined in the circuit through a suitable anti-inductive resistance, R, through which the current passes to the terminal, T, from which the course of the current through the coils to T_1 is indicated by the arrows in the diagram; the switch handle, H, being in this case turned to "volt." For the measurement of amperes the switch is turned to "watt"—a measured current passed through the suspended coils *c* and *d* of the balance, and the current to be measured passed through the strong-current coils, *g*, *h*, by introducing the electrodes E, E_1, into the circuit. The current through the suspended coils may sometimes be measured by means of the instrument itself, arranged for the measurement of volts. This may be done by first measuring the current which the difference of potential between the supply conductors of an electrical installation, or between the poles of a battery, causes to flow through the four five-wire coils of the instrument and its external resistance, and then turning the switch to "watt," and at the same time introducing a resistance into the circuit equal to the resistance of the fixed five-wire coils. When the balance is used as a watt-meter, the switch is turned to "watt," and the terminals, T, T_1, joined to the supply conductors, while the current through the main circuit is passed through the coils, *g*, *h*. When the rate of working in an alternate current circuit is measured by such a balance, the anti-inductive resistance, R, must be so great that there is no sensible difference of phase between the currents flowing through the fine wire coils of the instrument and the electromotive force on the supply conductors, to which they are connected.

* Abstract of a paper read before the Philosophical Society of Glasgow.

THE MATHER STEAM DYNAMO ELECTRIC MACHINE.

The New York *Electrical Review* gives the following description of a very interesting invention just patented

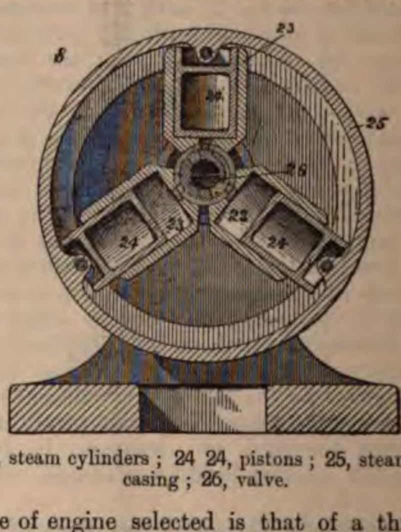
FIG. 1.—Mather Steam Dynamo.



1 2, field magnets; 3 4, pole-pieces; 5 6, bearings; 7, hollow shaft admitting steam; 8, engine (shown more fully in Fig. 2); 9 10, armature and ring; 11, commutator; 12, brushes; 13, coil connections; 14 15, binding screws for cable.

by Mr. R. H. Mather, of the Mather Electric Company, which we illustrate herewith, and the invention promises to have a wide field of application. It comprises a dynamo-electric machine, having a Gramme armature, in the interior of which is mounted a suitable type of revolving steam-engine, so that the steam-power is applied directly to the armature, instead of being transmitted through belting or connecting shafts. In other words, the driving engine is located entirely within the armature of the dynamo.

FIG. 2.—Steam Engine of the Mather Steam Dynamo.



23 23, steam cylinders; 24 24, pistons; 25, steam-tight casing; 26, valve.

The type of engine selected is that of a three cylinder engine, in which the three pistons receive steam in succession and rotate the armature in a manner which will be readily understood by referring to Fig. 2. The entire engine is contained within a steam-tight metal casing, and on the outside of this casing the armature is mounted.

On account of the necessity of boiler connections and the consequent liability to "grounds," the inventor has introduced an insulating connection in the steam pipe near the dynamo, which entirely insulates the engine and dynamo from the boiler. The steam is taken through the shaft at one end, which is hollow for the purpose, and the exhausted steam is discharged at the other end of the

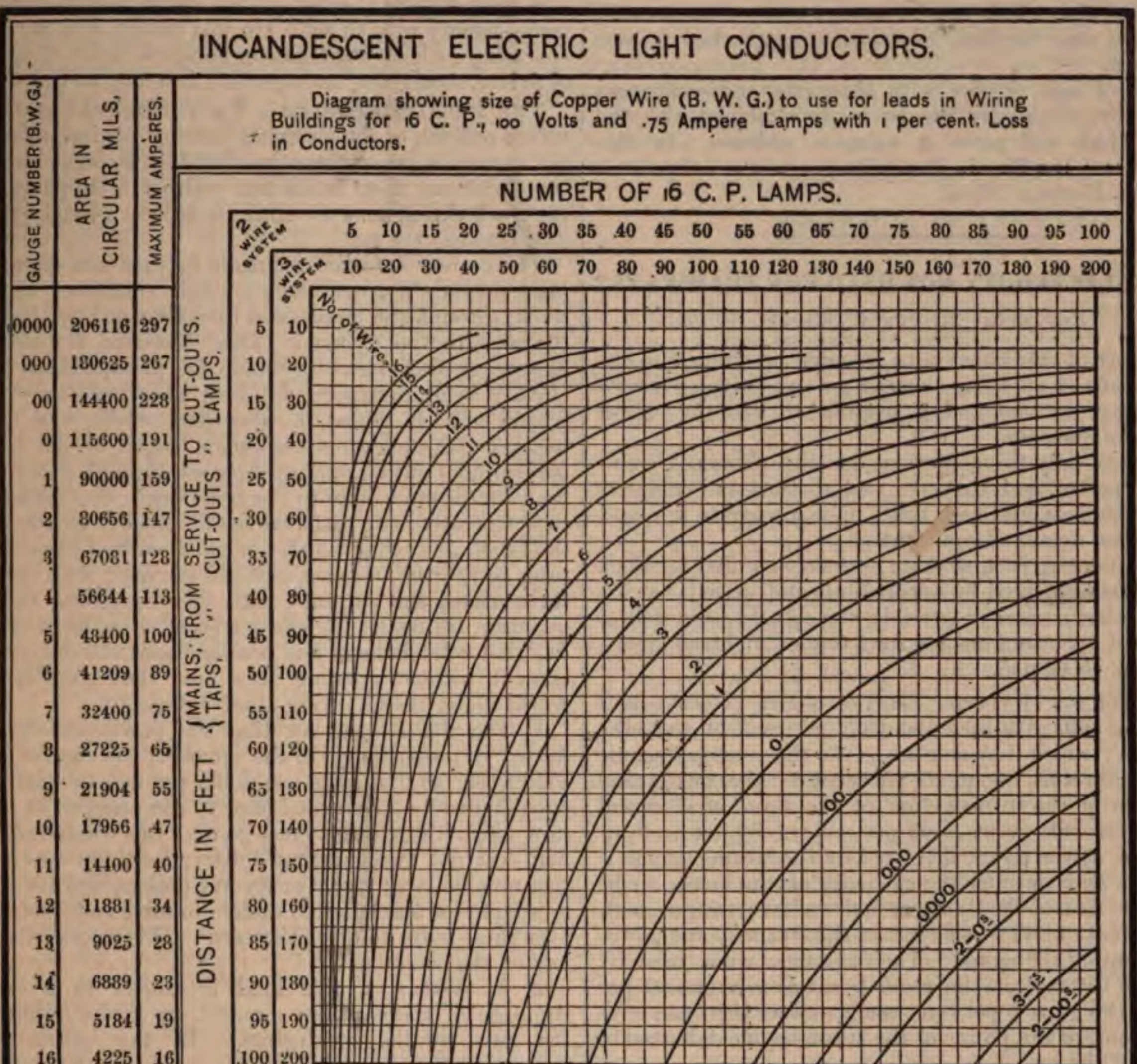
shaft in a similar manner. The construction is neat, and should be very effective in practice, as it does away with all the lateral thrust of the shaft on its bearings due to the transmission of the power through a belt. The extent of space occupied is inappreciable, as the otherwise waste space inside the armature is utilised for the location of the engine, and this enables the dynamo to be placed in the most confined situations without detriment. We presume the inventor is able to apply a reliable automatic cut-off valve to his special type of engine, so that it will be economical in use under varying loads.

DIAGRAM SHOWING THE SIZE OF CONDUCTORS FOR HOUSE WIRING.

BY C. H. CROCKETT, BOSTON.

In central station systems of incandescent electric lighting, a graphic method for determining the sizes of the conductors, for wiring the premises of customers, will be found to be much more convenient than any rule or formula however simple. The chances for mistakes are also less by the use of a graphic method than where repeated mathematical calculations are necessary.

In every healthy and growing central station there are, of course, many of these problems constantly occurring which differ from each other in only two of their factors, namely, the number of lamps to be installed and their distance from a given point. All the factors, such as the E.M.F. required at the lamp terminals, the economy of the lamps used, and the allowable fall of potential in the leads, are constants, the voltage and economy of the lamps depending on the particular system in use, and the drop in the leads being a certain determined percentage of the potential difference at the lamps.



A diagram which will meet all requirements, showing at a glance the correct sizes of wire to use, can be easily constructed for any system of lighting, and can be made of such dimensions as to be carried in the pocket.

All wiremen connected with a central station should be furnished with blue print copies, and the wiring of stores, offices, residences, &c., should be in strict accordance with the values given by these diagrams.

A practical example of such a diagram is here presented. It was designed for 100 volt ·75 ampere 16 c.p. lamps for the two or three wire system, with a loss of E.M.F. in the leads of one per cent., one half of this loss to be in the mains and one half to be in the tap or branch wires.

The method of using it is very simple, and is as follows: Follow the vertical line directly under the number representing the total number of lamps to be put in until it meets a horizontal line directly opposite a number corresponding to the average lamp distance of the cut-outs from the service-wires. The nearest curved line to this junction of the vertical and horizontal lines will be marked with the gauge number of the wire to use for the mains.

For a tap or branch wire, determine the number of lamps supplied by such wire and the average distance of these lamps from the cut-out or junction with the mains. Follow the corresponding vertical and horizontal lines on the diagram until they meet, and the nearest curved line will indicate the proper size of wire to use, as was the case with the mains.

As before stated, the diagram is constructed for use with the two or three wire system. For two-wire circuits the upper row of figures for the lamps and the left-hand column of figures for the distances are to be used; for three-wire circuits the lower row and right-hand column are to be used. The following two examples will illustrate the use of the diagram.

1. Required to find the size of conductor necessary to carry 20 16-c.p. lamps of the quality assumed to a distance of 40ft. on the two-wire system.

Answer: Following the vertical line under "20" at the top downward until it meets the horizontal line opposite "40" at the left, they intersect each other near the curve marked "8." Hence No. 8 B.W.G. is the size of conductor required.

2. Required to find the size of conductor necessary to carry 30 lamps 50ft. on the three-wire system.

Answer: Following the vertical under "30" in the three-wire column until it meets the horizontal opposite "50," also in the three-wire column, they intersect near the curve marked "12." Hence No. 12 B.W.G. is the size required.

It will be noticed that the curved lines representing the gauge number of the wires are cut off at their upper ends, stopping under the greatest number of lamps which can be supplied by the different wires without heating. The first curved line met in following down the vertical line under any number of lamps is marked with the gauge number of the smallest wire which can be used for these lamps with safety; how near the limit of safety is approached is also readily seen.

A table of sizes of wire, with their cross-sectional areas and safe current capacity, can be easily combined with the diagram, which will prove a valuable addition. In this particular case the Birmingham wire gauge was adopted.—New York *Electrical World*.

WHY IS ELECTRICITY NOT USED FOR TRAMWAYS?

BY PROF. SIDNEY H. SHORT.

The object of this paper is to examine carefully into the various means of applying electricity as a motive power for street railway traction, and, if possible, to find the answer to the above question.

There are only three systems for the electrical transmission of power, and they are each distinct and complete within themselves, and each relies upon a separate principle and not upon details of construction.

We will take up each of these systems and discuss them upon the data obtained by experiments and actual service, and determine, as near as possible, the actual cost in dollars and cents of operating one car for a day of eighteen hours, from 6 a.m. to 12 p.m.

THE STORAGE BATTERY SYSTEM.—Mr. Prescott finds that storage cells give back about 65 per cent. of the electrical energy which they consume. As the average dynamo machine will return about 80 per cent. of the mechanical horse-power of the steam-engine in the form of electrical energy, these cells returned 65 per cent. of 80 per cent., or 52 per cent. of the power delivered by the steam-engine.

Now, we may consider the efficiency of the motor to be the same as that of the dynamo, and we have 80 per cent. of 52 per cent., or 41·6 per cent. of the steam-engine power delivered up by the motor. The resistance wires used by the storage battery cars for regulation will consume 10 per cent., and the gears 5 per cent. more, and we therefore have 26·6 per cent. of the power of the steam-engine delivered to the axles of the car.

At the fourth annual convention of the American Street Railway Association recently held in St. Louis, the committee appointed to investigate the utilisation of electricity for motive purposes reported as follows:—"The result of two years working of the electric railroad at Zankerode, Prussia, on the storage battery system, showed that only 30 per cent. of the power of the steam-engine was applicable to the propulsion of cars, but even this compares favourably with the cable system." Experience has taught us that, on the average, ten mechanical horse-power must be delivered to the axles of an ordinary loaded standard gauge 16ft. car to provide for its starting quickly after its numerous stops, for running at a speed of eight miles per hour, including stops, and for overcoming the resistance of the track. The efficiency of the storage battery system being but 26·6 per cent., the steam-engine must furnish thirty-eight mechanical horse-power, and the battery 19·7 e.h.p. in order to obtain *10 h.p. at the wheels.* As, according to Mr. Prescott, it requires 126lb. of battery to furnish 1 e.h.p. per hour, it would require 2,482lb. to give the necessary 19·7 e.h.p. per hour, or 44,676lb.—over twenty-two tons—of battery to be handled for each car every day. Now, it will not do to put more than one ton of accumulator cells on a car in addition to the weight of the motor, and practice proves that it requires twice as long to charge as to discharge the cells, hence it would require three sets of cells, each set weighing one ton, to operate each car. Then, in order to furnish the power represented by the twenty-two tons, these sets must each be used seven or eight times a day, making a change of battery necessary for each car every forty-nine minutes. This is about the length of time a pair of horses are used on roads with heavy traffic.

On an average city railway system, where the line is ten miles long, and operates twenty cars, it would require, with the storage battery system, a steam plant of 800 h.p. working up to its capacity all the time, and sixty tons of accumulator cells. These cells would require changing fourteen times in every eighteen hours, making 420 changes, of two tons each, during the day. This would require two sets of men—twenty in each set. On this basis I find the cost of operating each car for eighteen horses to be $8.92, exclusive of driver, conductor, management, interest, and repairs.

THE PARALLEL SYSTEM.—We now come to consider the future outlook of the electrical railway as depending upon the system at present mostly used, that is, furnishing a constant pressure upon conductors which are supported above the track throughout the entire length, or placed in a conduit between the rails.

The current is sometimes made to pass out from a constant pressure dynamo along a single conductor above the track, through the motor, and then returned by the rails of the track to the dynamo. This, however, is exceedingly dangerous, and in no case should be permitted, as life has already been destroyed by such construction. When a second wire is added, as described above, the two run parallel with each other the entire length of the line, the current goes out on one wire, passes through a motor, and back by the other wire to the generator. If a second car is to be operated, two paths are made across from one wire to the other, and it takes twice as much current from the generator to run the two cars as it did the one; with three cars three times the current; with four cars four times the quantity, till finally the current becomes so large in quantity that conductors of any practical size will be unable to carry it without growing very hot. The parallel system works under the following disadvantages:—

1. The well-known law that the power lost on a conductor is proportional to the square of the current on that conductor; so if it costs one dollar per day to send current enough over a given conductor to run one car, to run two cars, twice the current must go over this conductor, which will cost not two, but four dollars; for three cars it would cost nine dollars; five, twenty-five dollars, and for ten cars it would cost one hundred dollars to force sufficient current over these wires to drive the cars. This refers only to the loss on the conductors.

2. A system of this kind is subject to a complete stoppage of traffic at any moment, by a wire falling across the two parallel conductors. In the meantime, the generator at the driving station would have its armature burned, or break its driving belt.

3. Upon this parallel system if a car were completely stalled, which is a common occurrence with street cars, either from an overload, being derailed, or having the brakes set, and the current were then turned full into the motor, it would be destroyed by having its coils burned out.

4. In this system the motors have a large amount of power at or near the driving station, but the power falls as the distance from the station increases. Cars should have the same power throughout the entire length of the circuit, in order to allow them to run faster towards the outskirts of the city, and make up their time.

5. Each motor on a parallel circuit depends for its power and speed upon the movements of the rest of the motors on that circuit, making it vary in speed, and require constant attention from the car driver.

6. The regulation of the motors, operated on these

parallel circuits, is accomplished by means of resistance coils being thrown into and out of the circuit. As it always requires power to send a current through a resistance, these coils are, from their very nature, intended to be power dissipators, and, therefore, consume coal without returning any useful equivalent. They are unscientific contrivances, and cannot be permitted in any perfect system of electrical distribution of power. In addition, these resistance coils are dangerous, as they become very hot, and have often set fire to the woodwork of the cars.

7. On all these parallel circuits a dynamo is used, which keeps up a pressure between the wires all the time, even when the circuit is broken. Any person coming in contact with these wires would sustain severe injuries, and possibly it would result in death if the pressure reached much over 400 volts.

Taking the same data used with the storage battery system—*i.e.*, 10 miles of track, 20 cars, speed 8 miles per hour including stops, 16ft. cars, loaded, 18 hours a day, 10 h.p. delivered to the wheels, efficiency of dynamo and motors 80 per cent., using copper wire ⅓in. in diameter, and a pressure of 400 volts between the terminals of the motors—I find the cost of operating each car for 18 hours to be 12·12 dollars, exclusive of management, drivers, conductors, repairs, and interest on investment.

THE SERIES SYSTEM.—A new method for propelling street cars has been developed through the application of the old, time-tried principle of driving an electric current through a number of electrical receptive devices and operating them all in succession before the current is allowed to return to the generator. This principle has been used for the past fifty years in the electric telegraph, where the current from a small battery is passed over a single wire and through all the instruments on the line in succession; and who would think of operating a telegraph line upon any other system? The operation of these telegraph instruments is simply electrical transmission of power on a small scale. For the past fifteen years the wonderful success of the arc system of electric lighting, where one current is made to pass through each lamp on the circuit in succession, has again demonstrated the practicability of the series method of transmission of power, and the fact that arc electric lighting has been such a financial success proves the economy of this method.

Why should we not apply this same principle to the transmission of power for driving street cars?

The advantages of this method of propelling street cars are as follows:—

1. In the series system of transmitting power, a simple, constant current is used, which does not vary in quantity no matter how many cars are operated upon the circuit; therefore, the power required to drive that current over a given conductor remains the same under all conditions of operation. If it costs $1.00 a day to send sufficient current over a conductor to run one car, it will cost the same for two, three, five, or any number of cars.*

2. Should a wire fall across the conductor in this system of electrical railway, the traffic would not be interfered with, as the cars would move on as before, and the generator at the driving station know nothing of the existence of such a "cross."

3. Upon this series system, should a car for any reason be completely stalled, no harm would be done to the motor.

4. In this system the motors have as much power at the most distant point from the station as at the station itself, for the same current passes throughout the entire line.

5. Each motor on a series circuit is independent for its power and speed of all the other motors. A car once set for a certain speed will continue to run at that speed until changed.

6. The regulation of the motors operated on the series circuit is accomplished by simply rotating the brushes around the commutator, no resistance coils or switches being introduced into the circuit to consume coal uselessly or set fire to the car.

7. Plain series-wound generators are used to operate motors in series, and should the wires break from any cause the dynamo would immediately go out of action, and no electric pressure would exist on the wire, which could be handled without the slightest shock. The pressure at the terminals of these series motors can easily be kept below 300 volts, therefore, would be harmless to either man or beast.

Still, using the same data as with the storage system, I find the cost of operating each car for eighteen hours to be $2.22, exclusive of driver, conductor, management, repairs, and interest on investment.

Benjamin F. Thomas, Professor of Physics at the Ohio State University, in an article in the Ohio State *Journal*, March 22nd, 1888, referring to the first road constructed on this new system, writes as follows:—"Two cars were run, each carrying a load of pig iron equal in weight to about one hundred passengers. They were run at various speeds, stopped and started on grades, and put to as severe a trial as could possibly arise in regular use. The cars were under perfect control, and were run up a part of the track rising three feet in one hundred, at a speed of thirteen miles per hour. The mechanical devices used on the line are simple and positive in action, and if a line should be built in the substantial manner proposed by Prof. Short, I see no reason why it should not operate regularly and satisfactorily. A speed of ten miles an hour with full loads, and including stops, can easily be made."—*Street Railway Journal.*

* This statement is manifestly wrong. The author seems to forget that larger engines and dynamos would be required to give the greater E.M.F. necessary to send a current through a series of motors than through a single one.—Ed. *E. E.*

PROSPECTS IN AMERICA.

The great and continual increase of electric lighting in America, in comparison with the comparatively quiet state of the industry in England, often leads young electrical engineers to look with some longing to a land whose scope is so vast and where new plants are so constantly being installed, and not a few English electrical engineers have found pastures new on the other side of the water. But a word of warning is certainly necessary for anyone contemplating such a step. Many young men have saved or obtained sufficient to reach the other side, and with little spare money, but great hopes and several letters of introduction to those in authority, have wandered forth to make their fortunes. On arrival they have found, to their dismay, that places in the east were not to be had; the great electric installations were hundreds, or even thousands, of miles across the mainland west; and they have found, moreover—a very distinctive feature of American society—that their letters of introduction, an "Open Sesame" of great potence in this country, have little or no importance in the land of freedom, where any man considers himself at liberty to call abruptly upon another, and where employers take practically little or no notice of mere friendly introductions. An introduction from the highest would carry little or no weight, competence being the great voucher. A certificate of proficiency from a college or from a well-known electrician would, of course, carry weight, but influence as known in England is practically missing. A certificate also of mere book proficiency will serve nothing. The electrician there must know how to handle his tools quickly and skilfully, must be sharp in business capacity, and have a sufficient stock of ready money to tide him over the first few months of waiting and enquiry, and to carry him, may be, a long journey across west. Many of the most successful electricians of America have come from England, and "Britishers" are always appreciated; but any young electrical engineer intending to go across should first wisely realise the conditions which will confront him.

M. de Wroblewsky.—The death, consequent upon an accident in the laboratory, of this Austrian *savant* is announced as having taken place at Cracow. His name will be associated with the study of phenomena occurring at low temperature; and amongst these the continuous diminution with temperature of the electrical resistance of copper is not the least interesting

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

GOING FOR THE TECHNICAL PRESS.

The humorous badinage of Mr. Preece at the expense of the technical papers last week at the Society of Telegraph-Engineers, in conjunction with other remarks made at the same time and place, are rather rousing incentives to a retort courteous. Leader writing should be abandoned, because, forsooth, if nobody reads the leaders in the *Times*, ergo nobody reads the leaders in the technical papers. Such is the argument *à la* Preece. We are to restrict ourselves to facts, and never give opinions under penalty of excommunication, though some unreasoning creatures will urge that facts give rise to opinions, which frequently lead to experiments, and thus on to more facts. The time has hardly come yet when we may venture to write upon the tomb of Progress, *Requiescat in pace*. Really, life is too long to be able to deal with nothing but facts. Further, all letters over a *nom-de-plume* are to be tabooed. They are tabooed in some countries, so much so that the ephemeral technical literature hardly ever contains anything in the shape of a letter. If correspondence is always to be signed, then should articles; and though one should talk boastingly about the courage of his opinions, there are times and circumstances and opinions held which, if the criticisms were to be put into writing over a true name signature, would cause all the courage to ooze out with the perspiration at the fingers' ends. Of course if nothing could be written but undeniable, undisputable facts, the matter would be different; but even Mr. Preece expresses the opinion that there should be but "one set of fire rules." Surely the poor downtrodden scribe may venture with trembling fingers to follow so good an example.

Taking a considerable leap as regards Mr. Preece's remarks, we should like to consider for a moment the enormous question raised at the conclusion of his paper as to the education of the future Electrical Engineer. We will arrogate to ourselves a position and a knowledge that Mr. Preece refuses the technical papers, and say that the necessary education must come, and can come only, by the aid of the technical press. Mr. Preece's opinion as to the valuelessness of the technical papers weighs as nothing when compared with the facts of the case. His education, the education of every man who holds a position in the world, is obtained in two ways—by experience, and from current literature. School books are mostly written or compiled by men who know nothing practically of the subject upon which they write, and the more pretentious and costly books, however carefully written, and however rapidly edition follows edition, are generally months, if not years, out of date. The books that are far ahead of the time are few in number, and are almost wholly connected with pure science. Men do not read current

literature as they should do. We know that the strong meat is therein usually diluted with an abundance of verbosity, that makes one who is really abreast of the times frequently cry out, Words, words, nothing but words. Practical men, as a rule, have no talent for condensation; they meander along painfully and verbosely, but the kernel is there, and the learner has to find it, or stand back. Experience is gained to the extent of at least 95 per cent. by reading current literature. The chemist does not need the experience of the girl who, to clean out a glycerine bottle, poured in a little nitric acid, and followed the doctorial formula, "to be well shaken before taken." Experience does not necessarily mean trying an experiment yourself, or seeing it tried. Experience in some instances may be gained from a speech or from a paper just as well, if not better, than in the laboratory or the workshop. It has been the custom in England to ridicule the technical press. It is the downtrodden worm that never turns. The Lord Mayor never makes merry with its members at the Mansion House, nor does a Prime Minister ever condescend to acknowledge its existence by the gift of medals and decorations—putty or otherwise. It is tolerated, not loved, in most businesses—despised if it happens to express any opinion contrary to the notions of the reader, flattered if anything is to be gained thereby, kicked with impunity because its traditions are totally against such low and hurtful occupations as duelling. The technical press can afford to make merry over the criticisms against it, inasmuch as no one will take these adverse knocks seriously, but as in reality directed against one or two offenders, through whose offences the whole "in a loomp is bad," as Tennyson has it.

There is still one other matter against which we feel inclined to rebel—viz., to the statement that the responsible authorities of the technical papers—still "in the loomp"—did not make sufficient efforts to obtain information first-hand as regards the "fire rules" and the negotiations between the committee and Mr. Heaply. We do not think the criticism was intended to extend further, and even so far the accusation was too sweeping. We can at any rate speak to the fact that at least one paper knew the position of both parties at first-hand, and Mr. Preece's expressed wish over and over again reiterated during the reading of his paper, was but a modification of the last sentence of our note of April 13 as follows: "We regret that some way has not been found to bring the conflicting interests into agreement." We refrained from commenting upon the "society's rules," or in any way expressing opinions that might further tend to widen the breach, hoping that the multiplication of office rules would intensify the feeling among the best contractors that ten—or two—sets of rules are bad, and that sufficient influence would be brought to bear upon the offices to bring them into accord. The tendency of the paper and the discussion which followed was to bring about the consummation of this happy state of things, and we trust the further discussion will bring about a final settlement pleasing to all parties concerned.

REPORT UPON JARMAN'S ELECTRIC TRAMCAR.

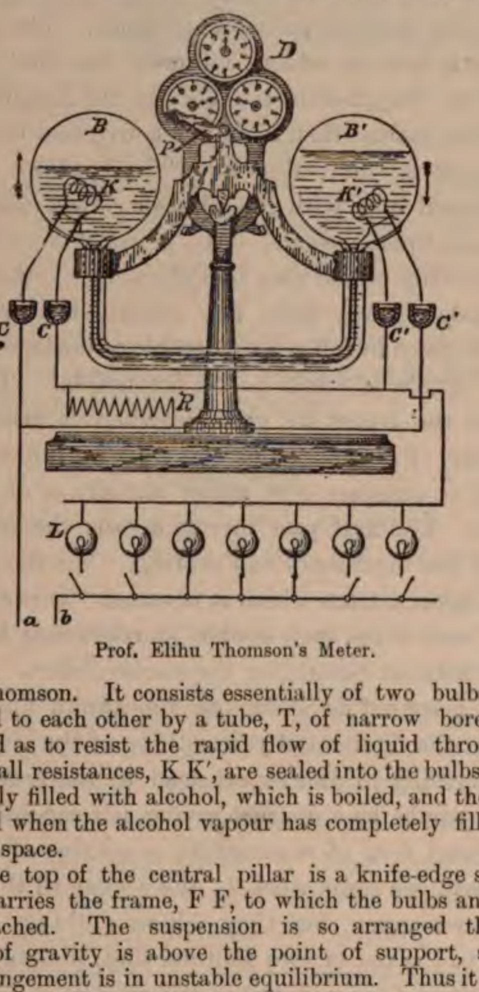
Elsewhere we insert a report of an experimental run of this tramcar. A purpose is to be served by this report, in that, whether it be considered from the scientific or the commercial standpoint, it is altogether faulty. On the one hand, it errs in saying what might be well left unsaid; on the other, it leaves unsaid what ought to be said. Whether it is right for us to state facts and ignore opinions, is a question of some importance when matters of this kind are under consideration. One section of the reading public, having little knowledge of technical matters, looks to the techical press for guidance. The advice given, it is true, is seldom followed, but that arises more from the inherent tendency of the Englishman to gamble, rather than from the conviction that the investment is safe. Reports of the kind we notice are obtained only with the ulterior object either to get money upon patents, or to promote a company. The investing public may be influenced by sentences judiciously chosen from any report, but when a report is given in full a considerable advantage arises, as the whole is taken to be favourable. To the initiated the report we give elsewhere is absolutely colourless. From it no one can gain the information required to compare cost, either initially or of maintenance. The first part merely details the arrangement of the machinery and gearing. We then have certain figures, from which it is stated "it is evident that at least three such double journeys may be performed without recharging the accumulators." Now we are prepared to stake our reputation upon the fact that the figures tell you nothing of the kind, nor does anything in the report lead to the proof that "there would be a distinct saving per car-mile over the present cost of maintaining a number of horses to perform the same work." We accept all the facts and figures given, but they tell us nothing. With regard to the use of two motors, that, perhaps, may be a matter of opinion, but in our opinion one only is required. Gearing neither complicated nor costly can be fitted so as to drive in either direction with the motor running constantly in one direction. A cabman does not take out two horses to work his cab for fear one should break down. Yet horses do break down, as do machines. A motor is a machine, but we no more expect it to break down at its ordinary work than we do a locomotive, and the sooner the insane idea about duplicating everything electrical is knocked on the head the better. Messrs. Immisch will gladly supply any number of motors,

and will guarantee these motors to run as well as any other class of machinery without breaking down.

The figures we want should show the actual cost, all things considered, per mile run. We require to know a good deal more about weights than can be found in this report. Far more information is given in Prof. Short's paper, though even this must be read *cum grano salis*, because the author is professedly the advocate of a particular system.

THOMSON'S ELECTRIC METER.

For the purpose of obtaining a meter which shall register the amount of current, either continuous or alternating, passing through a circuit, Prof. Elihu Thomson has recently constructed an ingenious form of meter, in which the heating property of the current is employed as a means of effecting motion in a registering train. The accompanying illustration shows one form of the apparatus designed by



Prof. Elihu Thomson's Meter.

Prof. Thomson. It consists essentially of two bulbs, B B', attached to each other by a tube, T, of narrow bore, or so arranged as to resist the rapid flow of liquid through it. Two small resistances, K K', are sealed into the bulbs, which are partly filled with alcohol, which is boiled, and the whole is sealed when the alcohol vapour has completely filled the interior space.

At the top of the central pillar is a knife-edge support which carries the frame, F F, to which the bulbs and tube are attached. The suspension is so arranged that the centre of gravity is above the point of support, so that the arrangement is in unstable equilibrium. Thus it cannot rest in a middle position, but tips either way, according to the excess of weight on either side. Mercury cups, C C and C' C', receive alternately the ends of the wires leading to the coils, K K', in accordance with the position of the bulbs, so that when B is down the coil K is in circuit, and the coil K' out of circuit, and vice versa. While the wires dipping into the cups, C C, may be arranged so as to make contact just before the others in C' C' break their contact, this need not be the condition, for, by interposing a resistance, R, as a bridge, the circuit is maintained, even though a break should occur between C C and C' C'. The operation of the apparatus will now be readily understood. Assuming the bulb B to be depressed, so that its heating coil K is in circuit, if a certain number of lamps, L, be fed by a current, the coil K will be fed by a definite proportion of it, and will cause a slight warming of it in the liquid in the bulb B. This will result in depressing the level of the liquid in the bulb, due to increased vapour tension and a resisted flow of the liquid through the tube, T, into the bulb B'. This action continues until the accumulated weight in the bulb B' is sufficient to tip the apparatus over and connect the coil K' instead of the coil K in circuit. The reverse action now takes place, resulting in a depression of the level in the bulb B', and an elevation of that in bulb B, until an overbalance is reached, when the arm is again tilted, and so on. At each complete oscillation the pawl, P, moves the register and counts a definite amount of current consumed.

EFFECT OF CHLORINE ON THE ELECTROMOTIVE FORCE OF A VOLTAIC COUPLE.*

BY DR. G. GORE, F.R.S.

If the electromotive force of a small voltaic couple of unamalgamated magnesium and platinum in distilled water is balanced through the coil of a moderately sensitive galvanometer of about 100 ohms resistance, by means of that of a small Daniell's cell plus that of a sufficient number of couples of iron and german silver of a suitable thermo-electric pile (see *Proc.* Birmingham Philos. Soc., Vol. iv., p. 130), the degree of potential being noted, and sufficiently minute quantities of very dilute chlorine water are then added in succession to the distilled water, the degree of electromotive force of the couple is not affected until a certain definite proportion of chlorine has been added; the potential then suddenly commences to increase, and continues to do so with each further addition within a certain limit. Instead of making the experiment by adding chlorine water, it may be made by gradually diluting a very weak aqueous solution of chlorine.

The minimum proportion of chlorine necessary to cause this sudden change of electromotive force is extremely small; in my experiments it has been one part in 17,000 million parts of water;† or less than one 7,000th part of that required to yield a barely perceptible spacity in ten times the bulk of a solution of sal-ammoniac by means of nitrate of silver. The quantity of liquid required for acting upon the couple is small, and it would be easy to detect the effect of the above proportion or of less than one 10,000 millionth part of a grain of chlorine in one tenth of a cubic centimetre of distilled water by this process. The same kind of action occurs with other electrolytes, but requires larger proportions of dissolved substance.

As the degree of sensitiveness of the method appears extreme, I add the following remarks. The original solution of washed chlorine in distilled water was prepared in a dark place by the usual method from hydrochloric acid and manganic oxide, and was kept in an opaque well-stoppered bottle in the dark. The strength of this liquid was found by means of volumetric analysis with a standard solution of argentic nitrate in the usual manner, the accuracy of the silver solution being proved by means of a known weight of pure chloride of sodium. The chlorine liquid contained 2·3 milligrammes, or ·03565 grains of chlorine, per cubic centimetre, and was just about three-fourths saturated.

One-tenth of a cubic centimetre of this solution ("No. 1"), or ·003565 grains of chlorine, was added to 9·9 c.c. of distilled water and mixed. One cubic centimetre of this second liquid ("No. 2"), or ·0003565 grains of chlorine, was added to 99· c.c. of water and mixed; the resulting liquid ("No. 3") contained ·000003565 grains of chlorine per cubic centimetre. To make the solutions ("No. 4") for exciting the voltaic couple, successive portions of 1-10th or 1-20th c.c. of "No. 3" liquid were added to 900 cubic centimetres of distilled water and mixed.

I have employed the foregoing method for examining the states and degrees of combination of dissolved substances in electrolytes, and am also investigating its various relations.

* Read before the Royal Society, May 3, 1888.

† As one part of chlorine in 17,612 million parts of water had no visible effect, and in 17,000 millions had a distinct effect, the influence of the difference, or of one part in 500,000 millions, has been detected.

ELECTRIC LIGHTING.

Proposed conditions of contract under which electric light wires may be laid in the streets of Paris :—

Continued from page 451.

CHAPTER III

Responsibility.

ART. 23.—The licensee shall be responsible to the town and to any other party for any damage consequent upon the installation, the presence, or the working of electrical conductors.

Moreover, the licensee renounces any right of taking proceedings against the town of Paris in consequence of damage occurring to his system of conductors or installations, by reason of accidents due to work carried out on the public way or to any other cause. He preserves his right of proceeding against any other party, but declares that he renounces the right of taking proceedings against the town of Paris.

Security.

ART. 24.—As a guarantee that the above-mentioned obligations will be duly conformed to, the licensee is to deposit as security at the municipal counting-house a sum of ——.

The security is to consist of French funds, or bonds of the town of Paris, at the mean rate prevalent on the day prior to the deposit. The interest thereon will be drawn by the licensee.

Fines.

ART. 25. Any neglect of the clauses in the conditions of contract, or any infringement of the rules in force or the directions laid down by the Administration within the limits of the rights conferred upon it by the conditions of contract, will incur the application of a fine of 50fr. for each infringement, and for each day until the execution of the directions, without its being necessary to proceed in due form of law and without prejudice to the application of the clauses relative to the withdrawal of the authorisation.

The amount of these fines, as well as legal expenses, will be deducted from the amount deposited as security, which amount must be reconstituted at its original value within the maximum period of one month after the said deduction.

In case of insufficiency or of non-reconstitution of the security, the administration shall have the right to seize the working plant of the licensee until payment be duly made.

These provisions are equally applicable in case the licensee shall not pay over at the municipal counting-house, within the stated period, the dues to be paid by him to the town in virtue of the present conditions of contract.

Proportion of Foreign Workmen and Conditions of Work.

ART. 26. The proportion of foreign workmen employed by the licensee shall not exceed one-tenth of the whole.

The working day shall be of nine hours.

The working hour of the electrical and mechanical workman shall be paid at the minimum wage of 0f. 80 centimes from 6 in the morning to 6 at night, 1f. 20 centimes from 6 p.m. to midnight, 1f. 60 centimes from midnight to 6 a.m.

These minimum prices shall be revised every five years, and shall vary in the same proportion as the mean salaries entered on the list of the town of Paris. For work that may be specified in these lists the wages shall be in accordance with the said lists.

French Materials.

ART. 27. All the materials employed shall be of French manufacture.

Authorisation to be obtained outside of the Municipal Administration.

ART. 28. The licensee will be bound to obtain, in due course, any further authorisations which may be necessary outside of the Municipal Administration of Paris.

Election of Residence.

The licensee shall preferably have registered offices in Paris. In case he should not do so, any notification or information addressed to him at the office of the secretary of the Prefecture of the Seine shall be valid.

Expenses of Stamps and Registration, Taxes, Contributions, &c.

ART. 30. The cost of stamping, registering, printing, and all other costs consequent upon the present authorisation shall be met by the licensee.

The same applies to all taxes and contributions, of whatever nature they may be, which may arise in consequence of the present authorisation.

The present conditions of contract are drawn up by the Director of Public Roads and Promenades.

ELECTRICITY FOR INCREASING THE TRACTIVE ADHESION OF LOCOMOTIVES AND MOTOR CARS.

The Commissioner of Patents, on March 21, granted to Messrs. Elias E. Ries and Albert H. Henderson, of Baltimore, Md., three patents on methods and apparatus for increasing the tractive power of locomotives and other self-propelled railway vehicles by electricity, which promise to be of very considerable importance both from a scientific and practical standpoint.

These patents cover broadly the use of an electric current for increasing the frictional adhesion between the driving wheels and rails, and the patentees have found that by this means the tractive power of locomotives and self-propelled motor cars can be nearly doubled without any increase in their weight, and also that no retardation is offered to the motive power by reason of the traction.

This system claims to make railroading practicable in spite of storms of snow and sleet, and surmounts as well as other difficulties that steam and street railways now have to contend with.

This increased traction is due to a temporary molecular change in the metal at the points of contact between the driving wheels and the track rails, caused by the passage from one to the other of a "transformed" electric current of large volume and small electromotive force or pressure.

The current is generated, according to one of these patents, by a small dynamo-electric machine carried by the locomotive, from which, after being passed through an electrical convertor, it is made to pass through, and traverse in succession, all of the driving wheels and that part of the track rails lying between them, which latter serve to complete the circuit as the locomotive or motor car moves along. The amount of increased traction thus obtainable is described as being very great, and can be regulated to suit the requirements by means of a simple switch that controls the flow of current through the "traction circuit."

An important peculiarity of this invention is that the tractive adhesion is not affected by snow or ice on the tracks, since the normal heat of the transformed current produced at the point of contact can be increased sufficiently to instantly vapourise any moisture that adheres to the surface of the rails, thereby clearing the rails as fast as the locomotive or motor car passes over the road.

In experiments recently made by Messrs. Ries and Henderson, before several of the U.S. Patent Office Examiners, the fact that the passage of the electric current increased the tractive effects in the manner claimed by them was thoroughly demonstrated, and a small railway car, equipped with the device, ascended and descended without the least difficuly a grade of 40 per cent., or 2,088ft. to the mile, whereas a 7 per cent. grade in practice can be surmounted only with the greatest difficulty under the most favourable circumstance by ordinarily equipped locomotives.

The apparatus is very ingenious, and has the appearance of the greatest simplicity. If all the claims made for the system are realised in practice, there can be no doubt but that it will work a revolution in railway operation, produce as fully as great a change in the manipulation and safety of steam railways as did the adoption of the air-brake, and supply the missing link to a successful operation of street cars by electricity.

By its means, the inventors claim, it becomes possible to ascend the steepest grades under all conditions of the

weather with perfect safety; slipping of the wheels upon the rails, especially noticeable in wet weather, and the consequent loss of time now resulting from this cause will be entirely avoided; faster speed can be attained, and trains can be started and stopped within less time than is at present occupied, because of the increased grip of the wheels when starting, and the prevention of what is termed as "skidding" when the breaks are applied; and last, but not least, a locomotive or motor car can, without any increase in its weight, draw nearly twice the load it is at present capable of moving, and this, it is claimed, at less cost than, and without the wear and tear occasioned by, the sand now ineffectually used for this purpose by railroad companies.

Owing to the extremely low tension of the currents of electricity employed in this system, there is absolutely no danger of shock or escape of current, and only that portion of the rails lying immediately below the locomotive is charged by the traction circuit. This method of increasing tractive adhesion formed the subject of an elaborate paper read by Mr. Elias E. Ries before the American Association for the Advancement of Science, at their last annual meeting (see Sci. Am. Supplement for Dec. 10, 1887), and elicited a great deal of favourable comment at the time, in view of the novelty and importance of the principle involved.—*American Engineer.*

JARMAN'S ELECTRIC TRAMCAR.

We have received a report by Messrs. Fredk. Walker and Hyde on Jarman's Electric Tramcar, which reads as follows:—

"In accordance with instructions received, we conducted an experimental test of the efficiency of Mr. Jarman's system of electrical traction during a trial run from Clapham to Westminster Bridge and back on the 10th inst.

"The whole of the locomotive machinery is arranged beneath the floor of the car, and comprises two series electric motors, both armatures of which are mounted upon one spindle, a wrought-iron pinion of twelve teeth being keyed centrally upon said spindle, the motion being thus transmitted to an intermediate shaft; the motor pinion gears with a mortice wheel of 48 teeth, and a second pinion of 24 teeth also keyed upon the intermediate shaft, gears with a similar mortice wheel of 48 teeth keyed upon the driving axle of the tramcar. The peculiarity of the gearing lies in the fact that the mortice wheels above referred to are geared with cogs formed of vulcanised fibre, and flanges are extended up to the top of the tooth, the whole being secured by pins passing through the width of each cog at the pitch line, and which are riveted over through the flanges. The motors are arranged so that while one is propelling the car in one direction, the armature of the other is rotating freely within the corresponding field, thereby allowing of the free circulation of air for cooling. In this way one motor may be used for the outward journey, and its armature may be cooled, while the other motor is performing the return journey. If additional power be required, both motors may be used at once. The reversal and control of the two motors is effected from either end of the car by means of levers acting upon double sets of brushes, and the regulating switch is also duplicated, so that the car can be driven from either end. An ingenious press contact enables the driver to operate an electric gong with his knee, and a lever brake, acting upon the high speed shaft, effectually checks the car, and brings it to rest immediately. The instruments used in taking readings for the following table were an Ayrton and Perry amperemeter and voltmeter, both of which were accurately calibrated and checked for the occasion.

OUTWARD JOURNEY.

Time of starting from Clapham	12:48 a.m.
" arrival at Westminster	1:10 a.m.
Average speed, miles per hour	8·43 miles.
Current at starting on level road	47 amperes.
Mean current during journey	25·5 amperes.
Mean E.M.F.	147 volts.

RETURN JOURNEY.

Time of starting from Westminster Bridge	1:35 a.m.
" arrival at Clapham	2:7 a.m.
Average speed, miles per hour, deducting two stoppages	7·83 miles.
Current at starting on a gradient of 1 in 20	69 amperes.
Mean current during journey	26·4 amperes.
Mean E.M.F.	142 volts.
Average e.h.p.	5·01 e.h.p.

Both armatures were perfectly cool.

"From the foregoing figures it is evident that at least three such double journeys may be performed without recharging the accumulators, allowing a fair margin for extra weight, bad state of track, weather, &c.

"The accumulators being arranged in trays, mounted upon wheels, and placed under the seats, may be run out through doors at each end *upon* a suitable track or platform upon the arrival of the car at the charging depôt, and in our opinion the operation of taking out the discharged cells and replacing them by others newly charged, could be performed by two men in five minutes.

"There were 23 persons upon the car, the general structure of which is much heavier than the modern cars of the same rating now being used upon the Metropolitan lines, and we consider that the whole system has been well designed and carried out in a practical and efficient manner, and if a charging installation for even two or more cars was laid down, there would be a distinct saving per car mile over the present cost of maintaining a number of horses to perform the same work, and that the system could be worked even on a small scale efficiently and profitably."

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—May 10.

The President, Mr. E. GRAVES, in the chair.

The paper was by Mr. W. H. Preece, F.R.S., Past President, on "The Risks of Fire incidental to Electric Lighting."

This paper seemed to be one more especially directed to put the position of the society in its connection with fire rules clearly and fully before the members and the public, rather than to consider any scientific questions involved in protecting buildings from fire risks due to their being lighted by electricity. No man could possibly be better put forward with this object in view than the author of the paper, who, though he managed to say a few pretty straight things all round, also bestowed almost as universally a modicum of praise. The one direction in which Mr. Preece hit out unsparingly was at the technical press. [The cap does not fit us, and we decline to put it on. If Mr. Preece wishes to hit out straight at us, he has only to say so, and we are quite ready to defend every action we have taken with regard to fire rules. It is not quite just to condemn indiscriminately when one particular culprit is aimed at.]

Mr. Preece commenced by explaining at some length the action of the society in appointing a committee, the constitution of that committee, the difficulties in the way of working a large committee, the negotiations with Mr. Heaphy, and the break between the committee and Mr. Heaphy. The sum and substance of all this comes to the fact that a difference of opinion exists, or did exist, between the committee and Mr. Heaphy. The former contend that the work of the committee consists in tabulating a number of general principles—abstract principles, if you like—not rules to be adopted by a fire office. The working rules must, they say, be special—framed, it is true, in accordance with these abstract principles, but nothing more. The one does not interfere the slightest with the other. The society deals with "pure science," leaving the fire offices to apply as they see fit, but contending all along that if the application agrees not with these principles, the offices will go wrong. Such, we gathered, was the argument of Mr. Preece. But the paper was not wholly devoted to the committee *v.* Heaphy. The author went on to indicate the necessity of following rules. He pointed out that we had scares where no danger existed, or could exist—as at Lord Brassey's; that, however, some disastrous fires have been traced to electric lighting. Very ably, succinctly, and clearly, he laid bare the dangerous spots in light installations. Gutta-percha and indiarubber had their uses, and for certain purposes were almost perfect, but not in electric lighting. Ammoniacal emanations from stables endangered the wiring and insulation. Ordinary cleansing operations found out danger spots; rats and mice were enemies to be greatly feared. Mercury was on no account to be used; though very handy, sooner or later the user had to pay the penalty. The worst of all plague spots were bad joints, bad connections, switches, and cut-outs. At this part of the paper there was some very plain speaking about bad workmanship—jerry installation work, as it might well be called. The technical papers, too, were damned as giving opinions and not facts, as attributing to greenhorns and to a happy-go-lucky committee statements which had been discussed by the most experienced members of the profession. [We could agree with Mr. Preece if he corrected his grammar—put the singular and not the plural, "a technical paper," not "the technical papers."] The author also stated that none of the technical papers attempted to get correct information—did not go to Mr. Preece or to the

committee. [Here, again, Mr. Preece is led astray in making a sweeping condemnation instead of a restricted one.]

With almost every other remark we cordially agree. Mr. Preece was in accord with most electrical engineers when he pronounced against more than "one set of rules." He contended, also, than for the first time in the history of electrical science a line of demarcation had been drawn by the committee, dividing high and low tension. Rule 32, he said, was the defining rule, which practically states that from henceforth all E.M.F.'s over 200 give high tension currents, all under give low tension. In conclusion, the author summed up the precautions to be taken to prevent accidents. We are to have proper design, proper construction, and proper inspection. Preferably, like Mr. Gordon, no joints at all; but if they must be, then be careful to have the best joints possible. Good workmanship should reign supreme, and under these conditions, and using a good insulator that was uninflammable, most of the dangers existing likely to create fires would cease, and the millennium of electric lighting would dawn. To get this happy state it is necessary to duly educate the coming race of electrical engineers.

In the discussion which followed the paper, Messrs. Heaphy, Hedges, Swan, J. Verity, Manville, Crompton, Siemens, and others took part, but for all practical purposes the remarks were directed against a multiplication of fire office rules, and it was more than once hinted that a way might be found whereby all existing differences would vanish. The meeting adjourned for a week, when Mr. Heaphy promised to fully state his view of the case.

Subsequently Mr. Preece exhibited a new insulator, which he thinks meets the wants of electric light engineers, and of which we shall have more to say in another issue.

STUDENTS' MEETING—May 3, 1888.

Mr. W. M. Mordey occupied the chair.

Mr. E. J. Rynes read a paper on "Electric Welding," describing the methods used by Prof. Elihu Thomson and by M. Benardos, the latter more in detail, the author having visited the works of M. Benardos at St. Petersburg, and having also seen his experiments at Paris. He had obtained many specimens, many of which he exhibited at the meeting. From his experience he stated many joints exhibited by M. Benardos appeared perfect outwardly, but when carefully examined the weld proved simply superficial.

Mr. Mordey said the paper, although a record of failures, was not less interesting or useful on that account. He thought that many of the failures made by persons who had experimented with electric welding were probably due to the fact that they were not sufficiently acquainted with ordinary welding, in which, perhaps, they would not have been much more successful. The amount of power used by M. Benardos was out of all proportion to the effect sought, and on this score the process of Prof. Elihu Thomson had a decided advantage. A probable application of the latter method would be in heating and soldering—not welding—conductors for street mains. He knew of no other means by which such an operation could be readily carried out. By this method it was possible to heat up a joint very quickly and to localise the heat.

Mr. Hume drew attention to the fact that electric welding had been used some three or four years ago by Messrs. Siemens for connecting rails at the Ryde Pier.

After some remarks from Messrs. **Marsh** and **Hayne, Mr. Rynes** replied.

Specimens of Thomson's electric welds were kindly lent by Prof. Forbes, to whom the thanks of the meeting are due.

A vote of thanks to the chairman concluded the meeting

PHYSICAL SOCIETY—May 12.

Prof. Reinold, F.R.S. (President), in the chair.

Mr G. L. Addenbrooke and Mr. H. A. Cunynghame were elected members of the society. The following papers were then read.

"Note on the Condition of Self-Excitation in a Dynamo Machine," by Prof. S. P. Thompson, D.Sc.

It is a well-known fact that a series dynamo running at a given speed will not excite itself unless the resistance is less than a certain value depending on the speed and construction of the machine, and if the resistance is slightly less than this critical value the excitation will not be such as to saturate the magnets. According to the primitive statement of the action of self-exciting dynamos on the "compound interest law," a dynamo should excite itself to saturation at any finite speed providing the resistance is not infinite. An explanation of the observed facts is given in the paper without any assumption as the curve of magnetisation. If E = E.M.F. of the machine, n = speed, C = number of wires on outside of armature, N = number of magnetic lines, i = current, S = number of turns on magnet Σ R, and Σ S the sums of the electric and magnetic resistances respectively, then $E = n\,C\,N$, $i = n\,C\,N/\Sigma R$, and $N = 4\pi\,S\,i/\Sigma S$. From these it is easily seen that $4\pi\,n\,C\,S = \Sigma S.\ \Sigma R$ (A)—*i.e.*, for a dynamo running at constant speed, the product of the magnetic and electric resistances is constant, and the dynamo will not excite itself if ΣR is greater than $4\pi\,n\,C\,S/\Sigma S$. Similarly, for a given value of ΣR, excitation is impossible if n is less than $\Sigma S.\ \Sigma R/4\pi\,C\,S$. For a value of ΣR, less that the critical value, the excitation increases until the magnetic resistance is increased, so that equation (A) is satisfied. The corresponding formula for shunt machines is $4\pi\,n\,C\,Z = \Sigma S\left\{(r_a\,r_s) + \frac{r_a\,r_s}{R}\right\}$, where Z = number of shunt turns, r_a, r_s, and R, the resistances of armature, shunt, and external circuits respectively. In the discussion which followed, Mr. Kapp described a method used in testing dynamos for determining the minimum speed at which the dynamos will excite themselves, and from thence determining the magnetic resistance of the air gap. In all cases, experiment showed this to be less than the calculated resistance, generally in the proportion of 1,500 to 1,860, the difference being greater in low tension machines. Prof. Ayrton pointed out that permanent magnetism was not taken into account, and that the apparent resistance, due to self-induction, and between the brushes and commutator were considerable for small currents.

Lord Rayleigh said Sir W. Thomson had shown critical speeds for given resistances to exist in Faraday's disc dynamo. He (Lord Rayleigh) did not approve of the term "magnetic resistance," and thought "reluctance," as recently suggested by Mr. Heaviside, would be preferable.

"On Magnetic Lag and the work lost due to Magnetic Lag in Alternating Current Transformers," by Mr. Thomas H. Blakesley, M.A.

The method adopted to detect the lag is to place dynamometers in both circuits, and one with a coil in each. Then, on the supposition that the E.M.F. of the secondary circuit is entirely due to the changing magnetism of the core, the author proves that the tangent of the magnetic lag angle must be equal to—

$$\frac{\frac{m}{n}\,C\,a_3 - B\,a_2}{\frac{m}{n}\,\sqrt{(A\,B_1\,a_1\,a_2 - C^2\,a_3^2)}}$$

where m and n are the numbers of turns in the primary and secondary coils respectively; A, B, C, the constants of the dynamometers, and a_1, a_2, a_3, their angular readings, A is such that $A\,a_1 = \frac{I_1^2}{2}$ where I_1 is the maximum value of the primary current. A table of actual results is given, where the magnetic lag is about $5\frac{1}{4}$ %. The whole power given out by the machine takes the form $r_1\,A\,a_1 + r_2\frac{m}{n}\,C\,a_3$ where r_1 and r_2 are the resistances of the primary and secondary circuits, while the power lost in hysteresis is expressed by $r_2\left(\frac{m}{n}\,C\,a_3 - B\,a_2\right)$. The lag is attributed to an induced magnetic stress called into being by the increasing or decreasing magnetism itself, and always opposing it, as motion in a medium induces an opposing force of friction. By supposing such an induced magnetic stress in quadrature (as Mr. Blakesley expresses it) with the magnetism, and of such a value as, when compounded with the stresses due to the currents, shall bring the resultant into quadrature with the secondary current, the effective magnetic stress is obtained. This involves a new idea, called magnetic self-induction, with its coefficient. The whole problem is treated by the geometrical method which the author has applied to several other problems in alternating currents.

Mr. Kapp, Profs. Thompson, Perry, and Ayrton, and Lord Rayleigh took part in discussing the paper.

"Note on the Conditions of Self-Regulation in a Constant Potential Dynamo Machine," by Prof. S. P. Thompson, D.Sc.

In "Dynamo Electric Machinery" a formula $\frac{Z}{S} = \frac{r_s}{r_a \ r_m}$ is given as expressing the ratio of the numbers of turns in the shunt and series windings of a compound dynamo. This is on the assumption that there is is no saturation within the working limits. As this assumption is not legitimate, a correcting factor is necessary. The factor is shown to be the ratio of the average permeability over the whole working range, to the permeability corresponding with no external current. The formula is transformed so as to be expressed in terms of the "satural" data of the machine, which, as shown in a previous paper, can be calculated from its details.

"On a Simple Apparatus for the Measurement of the Coefficient of Expansion by Heat," by Prof. W. E. Ayrton, F.R.S. and Prof. J. Perry F.R.S.

The apparatus consists of a metal tube, within which the wire or rod, whose coefficient is to be determined, is placed. One end of the wire is rigidly attached to one end of the tube, and the other end connected to an Ayrton and Perry magnifying spring, a pointer attached to which indicates the change of length due to alteration of temperature. Steam or water may be passed through the tube, the temperature of the wire being shown on a thermometer. The arrangement is very sensitive, and with a pointer about 20 c.m. long the motion is magnified about 1,000 times. A magnifying spring attached to an aneroid was also shown, and its great sensibility demonstrated. A combination of a spring of large diameter and pitch with one of small diameter and pitch was exhibited. By such a combination small rotations can be immensely magnified. The great features of the patent spring as a magnifier are the entire absence of friction and back lash, and the large range of proportionality.

A "Note on the Governors of Electromotors," by the same authors, and one on the "Electrical Action of Light," by Prof. W. E. Ayrton, were postponed until next meeting.

FACETIÆ.

Motto for a church: "Spare the rod and spoil the church."

The resistance of the human body, according to J. L. Sullivan, is very small, but has increased lately.

Death by Cable.—A Kansas correspondent says it is significant that there is a morgue at the foot of the cable tramway inclines in that enterprising city.

The Latest from America.—"Natural electricity" (!) has been discovered in America, in a disused pump well, and the pipe has become a permanent magnet—parts of the pump and pieces of steel adhering to it.

Another Fluid.—A man who fell to the ground in the street in New York, last week, was supposed to have received a shock from an electric light wire. It was subsequently learned that it was not "electric fluid," but an altogether different variety, which caused his steps to totter.

Electricity in the Hair Dyeing Business.—An overseer in one of the American mills has been taking shock from one of the large belts which is in rapid motion near his head, and his fine head of iron-grey hair has changed to a beautiful bay. No doubt, says the New York *Electrical Review*, the belts being leather, some of the tan colouring matter has been transplanted, electrically, into the hair, and gone into the dyeing business.

Kiel.—Messrs. Breman and Company are establishing a central station for distributing electrical power for arc and incandescence lighting at the works of the Imperial torpedo depôt at Friedrichsort, near Kiel.

ELECTRIC LIGHTING FROM CENTRAL STATIONS.*

BY R. E. B. CROMPTON.

The object of this paper is to put before you, the Society of Arts, some public data on which you can form your own opinions on the vexed question whether the electric light will soon be generally distributed as a means of lighting our houses. Although we see electric lighting extending on all sides in large establishments, many of you think that for some time to come it is likely to remain a luxury reserved for the rich. I hope, however, to show you that this need not necessarily be so, and that one very potent means of furthering its wider introduction is by making generally known the causes which are now retarding it. As all of you know, our private houses can only be lighted on an extended scale from central stations, and I wish to call your attention to the various points in which this central station lighting differs from the detached installations, which are now so well understood that they no longer present features of special interest. The plant for producing the electric light may be divided into generating and distributing apparatus. In a detached installation the whole system of engines and dynamos generating the electricity, as well as conductors distributing it to the lamps, is self-contained; generally within one building. At any rate, the system of conductors which connect the generating station with the lamps does not extend beyond the property of the consumer; but in the case of central station lighting the electricity is generated at a station placed more or less central to the area to be supplied, and from thence the conductors are taken through the public streets to be lighted, and it is this difficulty of dealing with the system of conducting mains which has so long retarded the investment of capital in systems of supply from central stations.

Lord Crawford and Mr. Ferranti, and others working with him, have within the last two years distributed electricity, by means of overhead wires, from a central station close to the Grosvenor Gallery. They have been able to do this because at the present moment no one has any control over the fixing of overhead wires. It is only necessary to obtain the consent of the householders of the roofs upon which it is proposed to place the supporting posts. Such a system of distribution has answered extremely well, so long as central stations have had to pick their customers far and wide, but the case will be very different when all the houses, or the greater part of them, take the light. When this is the case, it will be absolutely necessary to put the conductors underground. I myself am engineer to a company, which is successfully working a central station at Kensington, for supply to the houses around Kensington Gore and Knightsbridge, and in this case I have commenced by putting all my conductors underground, and have experienced not a few of the difficulties which I am about to describe.

As I believe the after-all cost of electric lighting will be the chief factor in determining its future extension, I think it best to commence by showing you that the main body of householders can only afford to spend a certain sum on their lighting, so that, if the electric light cannot be supplied for this sum, its use will be restricted. The usual laws of demand and supply will hold good when applied to the sale of electricity, as to any other commodity; that is to say, for equal profits the price can be reduced as the extent of the sale augments. But we must start with a sum which a householder can now afford to pay, and I think I can show you that, light for light, this sum may be considerably higher than that now paid for gas. Let us see what this amounts to. A Londoner who is tenant or owner of a house having three reception-rooms, ten bedrooms, and the usual offices and passages — in all, having about fifty burners fixed in them—spends about £25 a year for his lighting. His gas bill will be about £15; lamp, oil, candles, and matches, about £10; and his average coal bill will be about £25. But this £50 does not nearly represent the total cost of his lighting and heating. Repairs, renewals, cleaning of the house and furniture, inseparably connected with the lighting and heating, form a large item—in fact, a larger item than anybody would imagine who had not added them up and averaged them over a term of years. Although a great deal has been made of the damage done to ceilings, hangings, the bindings of books—in fact, everything fixed in the upper part of our rooms—by the fumes and smoke of burning gas, few people consider what a large share of the labour of our household servants is connected with cleaning grates, carrying coals, and the dusting of furniture, caused by the use of coal; how greatly the wear and tear of our carpets is increased by droppings from candles, by hot cinders falling from the grates, and by perpetual lifting to make way for the chimney-sweep, and by carrying coals up and down stairs.

A large proportion of the small repair bills we pay are in connection with the kitchen and other grates, hot-water boilers, gas fittings, candlesticks, lamps, and oil, and the like. In fact, it is not too much to say that if we dedutt the one important item of the repair of the exterior and the roof of the house itself, four-fifths of the remainder of our annual repair bills are

* Paper read at the Society of Arts, Wednesday, May 16.

spent in connection with lighting and heating. And it is quite certain that if electric light was introduced into such houses, and the bulk of heating and cooking done by gas, that this heavy annual bill would be considerably reduced, probably by £30 or £40 at least. Our householder could then well afford to pay £25 for his electric light, £20 for the increased quantity of gas he would use for heating, and, as English people will always insist upon an open grate in the drawing-room, £5 for wood fuel for this drawing-room fire. His pocket would then be the gainer of the £30 or £40 that he would save on repairs. We thus see our way for an income for the electric light company, providing that they can light a house for £25 a year, and this without ousting the gas company. The seller of house coals would no doubt suffer to some extent, but he would be partially compensated by selling steam coal to the electric light companies. Although this picture of the lion lying down with the lamb (*i.e.*, the gas company with the electric light company) seems almost to utopian to be realised, I think it deserves your most careful study and attention, for in its partial realisation we may have some hope of fighting the smoke and fog demon which overshadows our beloved London. And I assure you that if you, the householders, will play your part, by encouraging the use of gas cooking and heating, and by taking up electricity for lighting, we, the electric light people, will play ours and will supply the electricity.

I have above mentioned the sum of £25 a year as one that could be paid by a householder owning or tenant of a house of the size I have taken as representing the average, having 50 electric lights fixed. At present it has been found that supply companies cannot charge much less than 8d. per Board of Trade unit for electricity. Now £25 a year means a trifle over two units a day, and this is equal to only 31 lamp-hours if the large 20 candle-power lamps are used throughout ; but experience has shown us at Kensington that the nicest lamp to use is one of about 10 to 11 candles, taking 33 watts. The two units per day will be sufficient for 62 such lamp-hours, and practice has shown that this average daily supply is amply sufficient for the brilliant lighting of such a house as I have described, if due care has been taken in the placing of the lights, and arrangements are made to switch off the lights in such rooms and passages in which light is not constantly required. As with gas, so with electricity ; the burners that make up the bill are those that are constantly burning, such as lamps in the hall, in the various passages, staircases, &c. But there is no need for those who wish to be economical to burn electric lamps constantly in places corresponding to those it is necessary to keep gas constantly burning. The reasons being obvious, it is not worth while to frequently turn out the gas, and then be at the trouble of getting matches and relighting it each time a person goes backward and forward, whereas the handling of an electric-light switch is quite another matter. I have recently devised means by which the whole series of lights, from the entrance right up to the passages at the top of a house, can be turned on simultaneously from any part, either from the entrance or from the first floor, or from the top of the house, so that anyone coming home late and finding his home in darkness can light up the whole of the passages by one switch as he enters, and put the whole out again as he goes into his bedroom. By such devices as these, great saving can be effected in the quantity of electricity used, as the saving made in the current used by these constant burning lamps allows for a corresponding increase of lighting in the dwelling and bedrooms at other times. It is manifestly against the interests of the electric light that it should always be associated with an extravagant display of light. Where much light is given it must necessarily be expensive, and others are consequently deterred from adopting electricity. The best customers a lighting company can have are those who use their lights to the best possible advantage. It is far better for a lighting company to have to supply current to a large number of economical customers than to a smaller number of less thrifty ones. Another method by which the cost of the electric light may be greatly reduced to the householder is by the increased use of portable fittings, such as table standard lamps, removable brackets, and such like. Setting on one side the not inconsiderable saving to the householder of the cost of the fittings themselves, the mere fact that such fittings are used, considerably reduces the maximum number that can be intentionally or accidentally turned on at one time, and thus greatly reduces the size of the generating plant required to supply this maximum. Further than this, the smaller unit of light placed in a table is, of course, more efficient than lamps hung from the ceiling. Having shown you that you can have your electricity, and can afford to pay for it, I want you to understand the difficulties which beset the electrical engineer, who has to provide the system of distributing mains from the generating station to your houses. As I have before said, in this portion of the undertaking lies the whole of our difficulties. The regulation of these mains has been made the subject of an Act of Parliament, which has undoubtedly been one cause of retarding electric lighting in this country ; at any rate, it is difficult for anyone who has not himself been engaged in the work to realise the long and wearisome delays, and the obstructions thrown in the way of electric light companies striving to obtain the requisite permission to lay these conductors.

As I have shown above, we do not wish to be rivals of the gas companies ; we wish to live alongside of them. We believe there is room for both of us ; but still comparisons will be made, and it is only fair to say that the conditions under which we at present labour are not equally fair to gas and to electricity. The gas companies have certain well-defined powers and well-defined obligations. There has been no attempt to apply to them the doctrine, that all undertakings for public supply must have but a limited tenure only, and become the property of the public authority after certain fixed periods. It has been said over and over again that never more will such powers be given in perpetuity as are now given to the gas companies, but still every year parliamentary sanction is given to the new undertakings under the Gas Acts, which grant these very self-same perpetual powers. No one appears to have brought forward the absolute unfairness of this course ; but as long as this difference exists, it is manifestly a logical sequence that, as capital which will be employed by electric light companies will not have the same security of tenure as that employed by gas companies, the former will have to pay dearer for it. This feeling that the electric light companies are to pay ransom in some form or other has got so strongly into the minds of the various local authorities, whose permission must be first obtained before conductors can be laid in the streets, that it is at the present moment a very potent cause of delaying the introduction of the light. I have never been able to understand why clear-headed men of business sitting on our London vestries, when they set themselves to consider the applications of the electric light companies to lay conductors, appear to forget the most obvious principles which govern supply and demand. No doubt their dislike to the present commanding position obtained by the gas companies is their reason for the caution. They appear to think that unless they tie the electric light companies hand and foot the gas monopoly will be repeated, forgetting that, although the gas companies at present have the monopoly of lighting, the mere fact of the wide introduction of electricity would destroy this monopoly, and by introducing competition accomplish the very thing that they desire. Still more incomprehensible is the wish of some of these bodies to become themselves the suppliers of the electric light. Surely the enterprise is not in such an advanced state that sufficient data have been accumulated to show that public moneys may be safely invested in systems of electric supply. How can any member of a vestry or local board imagine that his board would be allowed to raise money on the security of the rates for the purpose of supplying electricity to only a part of the ratepayers ; but such, nevertheless, is the case. Many members do think so, and the operations of the electric light supply companies who are seeking permission to lay their mains are delayed accordingly. There is no need for local authorities to be thus chary in granting permissions to respectable companies, for they have ample means of protecting the interests of their ratepayers from a dear and inefficient supply of electricity. They are not able, even if they wish it, to grant any monopoly to any one lighting company to lay down their conductors in the streets, so that in the event of the first company abusing the powers given to it, either by charging too high prices or by not supplying a regular and constant service, they can correct the matter by allowing a second company to compete. An efficient service of electrical supply is very easy to define. As long as the E.M.F. or electrical pressure is kept constant, and there is no break of continuity in the supply, nothing further need be asked for, as electricity, not being a material substance, cannot be adulterated ; or, as Sir Frederick Bramwell once put it very happily, there is no need to define how many grains of sulphur is allowable in an ampere of electricity. In addition to the long and wearying delay of obtaining the consent of some of our local authorities (and it must be remembered that London is so split up, that it is very difficult to obtain a district which does not trench on ground of more than one vestry, so that the final consent of several vestries must be obtained before the work can be proceeded with in any portion of the district intended to be lighted), there are several other delays in the shape of permissions to be obtained from the Board of Trade and from the Postmaster-General. On the whole, it may be said that, as the law now stands, it takes nearly a year to obtain all the permissions that are necessary before the contractor who is to lay the conductors can break ground ; and it is obvious that if you, the English public, are really anxious for the light and intend to have it, you have it in your power to direct your vestrymen to be less obstructive. After all permissions have been obtained, an entirely new series of troubles are met with. Anyone of you who have seen a trench open in a London footway must have noticed the large number of small service pipes which cross the footway at right angles. These pipes are at all depths ; some of them close to the surface of the ground, some of them very much deeper. In most cases the footways pass over cellar arches. It will be seen

that there is very little space between the crowns of these arches and the under-side of the flags or the surface of the asphalte. But this small space is all that is available in which to lay the electric conductors, and our troubles in arranging to get them into it are not small. I should much like to use the French word "canalisation" for the whole system of conductors which convey the electricity from the central station right up to the lamps. We have no equivalent English term; the nearest expression that I can use is to call the "canalisation" the system of conducting mains. These conducting mains, the material they should be made of, and the best method of laying them, form the most difficult point that the electrical engineer has now to deal with. It is the one part of the plant which is hardly at all employed on private installations, even if these are of large size; consequently, we English engineers have had small experience to enable us to determine the best material to use and the best methods of laying. In America, where the progress of central stations has been so very great, in most cases overhead wires have been used, fixed to posts in the street, and which I do not think would be allowed at all in England, and certainly not in London. Nor is any great extension of the present system of overhead wires, such as you use radiating from the Grosvenor Gallery, likely to be allowed. We therefore have to devote all our energies to the best, cheapest, and most durable methods of laying our conductors underground, and, as far as possible, in the footways.

The various modes of laying the conductors may be divided into two classes. (1) By insulated cables, with the appearance of which you are all familiar, laid either in troughs, drawn into pipes, or into bitumen cases, or (2) by bare copper conductors, stretched on earthenware or glass insulators, in culverts, or small subways, formed just beneath the surface of the footway. One or other of the first methods are most commonly employed. But during the last year I have laid down in Kensington considerable lengths of bare copper conductor in culverts, as above described, with most satisfactory results. The completed conductor consists of such durable materials, and the facilities for repairs and renewals, and for exchanging or increasing the size of the conductor itself, are so great, that it is particularly suited for electric lighting at its present stage, when we are very uncertain as to the number of houses that each conductor will have to supply during the next few years. Our case is very different from that of the gas companies, who lay down their mains with the full knowledge that every house fronted by the mains will have to take the gas to a larger or smaller extent. We, on the contrary, having to compete with the existing supply, in most cases do not know what proportion of the houses will take the current. It is a great point, therefore, to be able to lay down a small conductor in the first instance, and be able to increase it by adding copper at a later date, and any system we employ must fulfil this requirement. If it were not for the many transverse pipes above mentioned, the culvert system I have described would best fulfil all the requirements, but unless these pipes can be all got below the culvert, or grouped so as to cross the culvert at regular intervals in masses of solid brickwork, it would not be safe to use the bare copper conductors, for when these stretch they might come in contact with these pipes, and so make an earth connection. For such places we have to effect a compromise, by using short lengths of insulated cable drawn into pipes or bitumen cases. However, we must also so arrange matters that we can alter, repair, or renew the cables without again breaking up the surface of the footway, and this we must do by having surface boxes with removable covers at frequent intervals through which access can be given to the culverts or to the pipes containing the conductors.

The probability that for some years to come we shall not supply the current to a considerable percentage of the houses fronted by the mains, makes it at present necessary to estimate for a great length of conducting mains in proportion to the houses supplied. After careful consideration, I have come to the conclusion that in London we cannot calculate on requiring less than twenty yards of main conductor laid for every house supplied—that is to say, for 1,000 houses we should require 20,000 yards of conductors; and as the cost of taking up and replacing the surface of an asphalte footway is about 11s. a yard, you will see that this item comes to more than £5 of capital charge for every house supplied. A great point would be gained if it were rendered obligatory on the gas and water companies to place their service pipes at a greater depth below the surface than they are at present, and this could be very easily arranged. If this could be done in all cases, so that culverts measuring eight or nine inches in the clear could be provided, it would make the laying and care of our conductors comparatively plain sailing, and would save enormous sums of money to the lighting company, and hence would re-act favourably on the cost of the light itself.

About half of the capital required for a central station supply system is required for the conductors themselves; so that I do not think that I have dwelt at too great length on this portion of the subject. Hitherto it has been the weak spot in all estimates, both for capital and maintenance, that we have been able to lay before intending investors; but the uncertainties, both as to first cost and cost of maintenance, are rapidly being removed, on account of the data we are obtaining from works recently carried out. We may now discuss the question of electric light supply companies as an investment for capital. I think no one will deny that enough has been done to show that electric light can be produced at a certain cost in detached installations, and I have shown above that the only unknown factor which introduces an element of uncertainty in the cost of production by central stations is the one of first cost and maintenance of conductors; but even if we charge the cost of production with the highest figures for cost of maintenance of conductors that are reasonably possible, we have ample grounds for showing that capital invested in electric supply will be highly remunerative so soon as the demand for lighting becomes general. Adopting the figures before given, viz., 8d. per unit, and estimating that the income from each house taking the light will average about £25 a year, I have made calculations that the company will cover its expenses and begin to pay dividends as soon as the number of houses taking the light exceeds 20 per cent. of the whole number fronting the mains. Roughly speaking, the capital required for plant of every description may be taken at £50 to £60 each house supplied. I think it is likely there will soon be a revulsion of feeling in favour of this class of investment. No doubt for some years we have been feeling the over-speculation in electric light shares which took place in 1881 and the years immediately following, when companies were promoted for the sole purpose of selling electric patents. The case now is widely different. As I have just said, the bulk of the money required will or ought to be spent in providing plant, of which half will be the cost of the conducting mains. I use the word ought, because at present the Parliamentary and other costs connected with obtaining permissions, to which I have called your attention, are very heavy, and I cannot help thinking that the greater part of it is unnecessary. One of the great enemies to the progress of central station lighting has been the wild promises that have been made by inventors of various forms of primary batteries, who are telling you every day that they will light your houses with some form of primary battery that can be put in your cellar, and which will require no attention. I have been over and over again told by my friends that they intend to have nothing to do with the electric light until they can get it in some simple form of this kind, and that they feel convinced that they will get it. The sooner the conviction is brought home to them that anything of the kind is absolutely hopeless, and that the large amount of electrical energy required for lighting your houses cannot by any possibility whatever be generated in the space available in a cellar, the better it will be for electric light prospects. I make this assertion confidently, as I know I have the whole body of electrical engineers at my back. I do not call inventors of primary batteries, or promoters of companies connected with them, electrical engineers in any sense of the word. They are in most cases self-deceivers who believe in their own promises, but they do not understand the most rudimentary laws of the conservation of energy or of the value of commercial products. One favourite bait they offer to an intending investor or intending user is, that he will be able to sell the waste products of his battery at a higher price than he gave for the materials originally put into it. They do not seem to see that the obvious question that everybody must at once put to them is—Why do not, then, chemical manufacturers at once adopt these batteries as the means of manufacturing this self-same product? But it is useless wasting words on this subject. I only wish to point out to you that every man who puts off the lighting of his house in the hope that some day some wonderful invention or improvement will be produced in the form of a primary battery is an enemy to the progress of the electric light. The capital for electric lighting must always, to a large extent, be invested in generating machinery and in distribution by means of conductors. In these conductors little or no progress is likely to be made further than in the direction I have indicated of an improved system of culverts to carry them. We know the generating machinery has already reached a high degree of perfection. Every day we hear of sets of steam-engines and dynamos returning the shape of electricity 75 and 82 per cent. of the energy put into the cylinder of the steam-engine. Having already obtained such high efficiences, we can hope for very small advantages to the consumer from further improvements in either generating or distributing plant. Doubtless great improvements will be made in the manufacture of the incandescent lamps we use. They may be made vastly more efficient, but every man using the electric light will be able to avail himself continuously of the improvements of the lamps by putting them in as his old ones wear out; so there is no reason why he should put off taking the light on this account. I have shown you that it will pay the householder handsomely to take the electric light now at the comparatively high price we must charge so long as only a small percentage of the houses take the light. Prices can be reduced and profits augmented simultaneously. The consumer will get the benefit of reduced prices, and the investor simultaneously will get

better profits as every man persuades his neighbour to take the light. We are told that the cost of wiring houses, and the fact that we have not yet got a trustworthy meter, are two formidable objects to the spread of electricity. It is quite true that no man likes to be called upon to spend £100 in putting in the wires and electric fittings in a house in which he has already spent a considerable sum on gas-fitting. The electric companies would no doubt be willing to furnish the wires and fittings on the deferred payment system; but, unfortunately, in the present state of the law they would be unable to retain any property in the wires and fittings during the time that the instalments remain unpaid. So that, in default of payment, they would not be able to take them back again, as the wiring and greater part of the fittings would remain fixtures, and the property of the landlord. It is possible that a clause might be introduced in the Electric Lighting Bill now before Parliament, putting electric light fittings into a different category to ordinary landlords' fixtures. At present, no householder who is near the end of a lease is likely to take up the electric light; and this matter obviously requires remedy. In conclusion, I have gone as rapidly as possible over the various matters which are affecting the introduction of the electric light into your houses. I have endeavoured, as far as possible, to adhere strictly to the subject of the paper, although in many cases sorely tempted to describe to you the various improvements and novelties that have taken place in connection with this most interesting subject. If, however, I have succeeded in bringing home to you what a powerful factor in the success of electric lighting is the intelligent co-operation of the public themselves who want the light, I shall feel that I have succeeded in my object.

So far I have kept this paper as little technical as possible, and have said nothing about the best system of distribution to be employed, or on the vexed question of transformers *versus* accumulators. I myself have recently read a paper at the Society of Telegraph-Engineers on this subject, and placed before that society the results of my investigations on the capital and maintenance cost of lighting a district of London by the two methods of alternating currents using transformers, and direct currents using accumulators. The general results arrived at, however, are before you in the tables which you see on the wall. Table 3 shows that the cost of generating and distributing plant, carried out on either of the above systems, will cost about £60,000 for plant sufficient for 1,000 houses of the size I have throughout spoken of. Table 4 shows that the working expenses of producing the electricity for these 1,000 houses would vary from £8,600 to £12,000, according to the system adopted the gross income in both cases being £25,000. This paper has been hotly discussed, but entirely from the point of view that all my prices both for capital charges and for maintenance were fixed too high. Without taking advantage of this opinion, the above figures give at length the data on which I have based the statement I have before made, that the question of electric light supply companies becoming dividend-paying concerns, depends almost entirely on the number of houses joined on to the mains. As the tables, which are based on the supposition that two houses out of every three fronting the mains will take the light, show that capital invested in plant ought to earn a dividend of at least 10 or 12 per cent. after putting aside sufficient reserve fund to meet depreciation and all such charges. The other two tables, Nos. 1 and 2, show you the cost of having 100 yards of double conductor underneath the footway of a London street—Table 1 by means of insulated conductors drawn into bitumen casings, and these figures will hold good if iron pipes or wood troughing filled in with bitumen are employed. Table 2 shows the cost of having similar conductors in bare copper strip insulated by porcelain insulators in the culverts. You will see that whereas in Table 1 the price per lb. of copper laid complete varies from 4s. 1d. down to 2s. 6½d. for heavy conductors according as the section is increased, in Table 2 the cost for equal sizes varies from 3s. 6d. down to about 1s. In both cases you will notice what an important part the cost of taking up and replacing the pavement bears to the whole cost of laying the conductors.

(For Tables, see *Electrical Engineer*, April 13, p. 343.)

Discussion.

Col. Innes, after complimenting Mr. Crompton on his paper, said that coming from America he felt like coming from light into darkness. Few people here, he thought, had any true idea how general the electric light was in America; the trains in passing along at night seem to be in continual twilight from the distant light from the towns. He had been informed on good authority that there was no town in America of over 10,000 inhabitants that was not lighted by electricity. With regard to primary batteries, he thought Mr. Crompton ought not to say that success would never attend the use of primary batteries. Mr. Crompton could not possibly know all the laws of Nature, and he thought that people had some good right in looking forward to a great development in the production of electricity by chemical means.

General Webber said he was greatly interested in the way Mr. Crompton had discussed the question from a different point of view from that taken at the Society of Telegraph-Engineers. One of the things which had struck him throughout the whole controversy, was that when gas was first introduced—he did not remember it himself, but had often heard of the question from Dr. Letheby—that great difficulty was experienced in getting a proper holder for the gas, and trouble often arose from supplying the gas direct from the retorts. No doubt this difficulty had been shortly overcome; still, it was some considerable time before a good gas-holder was produced—a far longer time than it has taken to get a good holder for use in electric lighting. Subject to certain improvement in manufacture of large quantities, which we may now expect, we have in the accumulator a safe, reliable, and efficient storer of electrical energy. As to overhead cables, they might be seen even now in London, crossing and recrossing the streets in a very objectionable fashion, and he was certain that such a system on an extended scale could not be a permanent one.

Mr. Bromhead asked whether the fittings could not be made movable so as to belong to the tenants themselves, and not to the landlords. He suggested that Mr. Crompton was too sanguine as to the use of gas in heating, which was very expensive for this purpose. Hot water and steam, as used on the Continent and in America, were far less expensive than gas. In America, the absence of gas works in new towns was no doubt one great cause; but the great secret of success was the use of water-power, which he would advocate in England.

Mr. Mordey wished to point out that out of 100 central stations in America, many paying good dividends, not one used accumulators. Accumulators had their place, in mansions, or where a few lamps were required all night; but on the merits of accumulators the electrical engineers, as a body, were at least divided. In the case of temporary high loads, there was no need to run the whole of the machinery ready to supply the greatest quantity; American companies were quite content to earn their dividends with direct driving plant. He would like to say a word as to underground cables. Many persons object to them for the reason that good insulation could not be kept at high potential underground. He would mention, as an interesting case, that of the City lighting, the current for which the Brush Company supplied for some years from Lambeth. The cable was an early one, poorly insulated with guttapercha and drawn through iron pipes, and the joints were not well made. Electricians would, no doubt, be surprised when he told them that the insulation resistance of this cable was often not greater than the copper resistance; yet it was found possible to keep a high-tension current in continual use in the cable. It was evident, from this fact, that electricians would not find much difficulty now in distributing high-tension currents in underground mains.

Mr. Swinburne advocated the use of gas heating, and with regard to the spread of electric lighting in London, said that few people had any idea of how much it had already spread. Half a million incandescent lamps were being sold a year for use in London alone, which showed, he thought, we were not so backward as some would have us imagine.

Mr. Addenbrooke said that too much was made of the unsightliness of overhead electric wires. He had a considerable experience in this respect, and as a rule it was their endeavour to get a row of poles along both sides of the street, in many cases so far back on the roof that the wires could not be seen, and crossing only at one end. It must be remembered, too, that electricity was forced to pick its customers; they had to persuade people to give up gas for electricity. An overhead wire could be easily taken to some considerable distance to a customer, around which centre other customers might soon come. If necessary afterwards, underground mains might be laid, but at present he thought overhead wires would lead to the greater development of the lighting.

A **Householder** said that the most important question of all was the certainty of the electric light, and he would like to ask Mr. Crompton on that point. He had been at St. James's Hall when the whole lighting went out, and on Christmas Eve many shops lost much of their custom through the Grosvenor supply suddenly failing.

Mr. Crompton, in reply, said that as to the question of primary batteries, he had the whole of the electrical engineers at his back. Gentlemen who believed that we were within measurable distance of an immense development in the shape of chemical production of electricity were, he thought, imperfectly educated. The whole question was one of the conservation of energy, and, in plain English, what these people expected was "perpetual motion." He would, however, point out that gentlemen who listened to these arguments might remember that the chief expense they were called upon to pay was that for wiring and fittings, an expense which would be the same whatever the source of the electricity. With reference to tenant right, £50 to £60 of every £100 was for wires, &c., laid into the wall or permanently fixed, and he might state that the Attorney-General, whose absence they deplored that night, had completely confirmed him on this point. With regard to overhead wires, if they could be carried as Mr. Addenbrooke suggested, that would certainly be the least objectionable way; but they must all know that in every street there were some cantankerous persons who refused their consent, and the wires had to cross the street and back again. This could very often be seen with telephone wires, at present in use, and what it would be with a complete system of electric light distribution it would be difficult to imagine. In America they had tall wooden posts down the side of the streets, but Londoners, though they will bear a great deal, would certainly draw the line at that. In advocating culverts he had, he said, thought it preferable to bring forward a scheme which is definitely *practical*; it *is* practical to have culverts in London, it is *not* to have posts or overhead wires for an extended system. With regard to expense for gas heating, it must be remembered that gas is now produced for lighting, and can be made much more cheaply for heating purpose; and as regards the objection made to the smell, if proper flues were made there was no more need to fear noxious fumes than the smoke of our fires. He could only say that, having used gas for heating at his own house, the servants were much better pleased, and he had experienced no trouble with fumes. As to the question of water-power, there was a good deal of misconception on this point. In the first place, we have not much water-power in England, and none in London; in the second place, for such a

system of distribution as he was advocating—if we had, the advantage would not be very great. The cost of steam-engines is now so small, and fuel and upkeep so cheap, that the cost of maintaining water works, dams, and races, would almost equal the total cost of engine power. In fact, with the total cost of installation of £59,000, there is only £2,100 a year for motive power, and if this were entirely swept away it would probably be quite equalled by the cost of interest on capital and upkeep of water works. The question of certainty was *very* important; nothing, he thought, did so much harm to the spread of the light as these sudden failures, and although they must not criticise a new system like the Grosvenor too much, yet he might state that at Kensington Court, for which he was consulting engineer, where accumulators were used, they had been working some 15 months, and had not had a single light go out from failure of current. He thought this was noteworthy, as the same thing could hardly be said even of a new gas company. At Vienna, again, they had been working for some years with accumulators without extinction or hitch of any kind.

A vote of thanks to the Chairman (Col. Hamilton, R.E., in place of the Attorney-General) concluded the meeting.

PARLIAMENTARY INTELLIGENCE.

THE CENTRAL TELEGRAPH OFFICE.

Mr. Fenwick asked the Postmaster-General whether it was true that the Treasury recently discovered that clerks employed at the Central Telegraph Office had for the past 18 years been paid a day's pay too much; whether two days' pay was deducted from the salaries of the staff after one week's notice; whether, as a consequence of this discovery, fortnightly payments had been abolished; and whether the clerks had complained of such change having been made in the mode of payment; and, if so, whether he would consider the advisability of paying those clerks weekly, as was done in several other branches of the Post Office service.

Mr. Raikes: In reply to the hon. member, I have to state that the over-payment to which he alludes in his question was brought under my notice by the Comptroller and Auditor-General. Most of the officers employed at the Central Telegraph Office are paid on a scale of annual salaries, and in consequence of payment being made fortnightly, an extra day's payment was made in ordinary years, and two days' extra payment in leap years. The question having been referred to the Treasury, it was decided that from and after the 31st of March, 1887, the actual annual salary only should be paid, and consequently, in making the last payment for the year to the 31st of March last, being leap year, the extra payment for two days was not made. As I was unwilling to alter the period of payment, I gave instructions that an advance of salary, calculated to the nearest pound, should be made in the middle of every month, the balance being paid at the end of the month. And I do not think it would be the wish of the officers that their wages should be paid weekly.

THE POST OFFICE IN EDINBURGH.

In answer to **Mr. Wallace**,

Mr. Raikes said: The office of the surveyor of the Midland District of Scotland is not part of the establishment of the Post Office in Edinburgh. In accordance with a rule applicable to the whole of the United Kingdom, the surveyor's stationary clerks are borne on the establishment of provincial post offices. The Post Office on the establishment of which the stationary clerks to the surveyor of the Midland District of Scotland are borne is Dundee; and it is only the salary which they would receive were they employed at Dundee that they receive as stationary clerks. Over and above this salary they receive a special allowance; but it is not the case that, in consequence of the withdrawal of two members of the Dundee establishment to act as stationary clerks, any one at Dundee performs higher duties or receives a lower salary than he otherwise would—the establishment having been specially adjusted to provide against such a contingency.

RAILWAY COMPANIES AND THE POST OFFICE.

Mr. Thomas asked the Postmaster-General whether the monopoly, in virtue of which he had directed railway companies to discontinue the conveyance of letter "per rail," was conferred upon the holder of his office prior to the introduction of the penny postal service; whether any further powers had been conferred in this respect upon the Postmaster-General during the past half century; whether any of his predecessors in office had ever interfered with the practice of sending letters needing expedition by rail; and whether, pending the inquiry by a departmental committee, he would allow the practice to be continued.

Mr. Raikes: The monopoly referred to by the hon. member was conferred upon the Postmaster-General long prior to the introduction of penny postage, and has been continued by various statutes up to the present time. There has been no extension of the Postmaster-General's powers in this respect since the Post Office Acts of the first year of her Majesty's reign. Representations have been made from time to time by successive Postmasters General to various carrying agencies as to the illegal carriage of letters. For my own part, I will say that, while every effort shall be made to effect an arrangement which shall be convenient to the public, and at the same time legal, I have not the power to sanction the revival of a practice which the law forbids.

COMPANIES' MEETINGS.

WEST INDIAN AND PANAMA TELEGRAPH COMPANY.

A meeting of the shareholders of the West Indian and Panama Telegraph Company, Limited, was held at Winchester House on Wednesday, **Mr. C. W. Earle** presiding.

The **Chairman**, in moving the adoption of the report, said the result of the half-year's work was most successful, considering that it was the poorer half of the year. It was the most profitable half-year since 1883. Most of them would be aware that the sugar crop took place in the first half of the year, and caused a good deal of telegraphing in connection with those crops. Therefore, the second half was not so successful in the way of revenue. The amount they received per mile was not equal to that of other transatlantic telegraph companies. As was the case in 1883, they had had a certain number of windfalls. They had had in the first place an increase of revenue, and in the second place they had chartered one of the ships to the National Ocean Company, which had relieved them of the maintenance of the ship, as well as earned money for the Company. In addition to these two circumstances there had been a profit on the exchange, which, generally speaking, caused a loss. They had also saved £250 on debentures. These combined enabled them to pay 10s. per share on account of the arrears of dividend on the First Preference shares. The amount added to the reserve fund was equal to the calculated amount of depreciation. That fund was well insured, and at present prices was worth £8,000 more than put down at. The repairs to the Porto Rico cable had been most expensive. It had cost altogether £31,000 in cable alone, to say nothing of the cost of the ships employed in the work. It was, however, absolutely necessary for them to carry out the repairs, inasmuch as the bulk of their work lay eastward of Porto Rico, and until this work was done they were depending for the bulk of their income upon one cable. When the report was issued, he had hoped to be able to say, for the first time, that all the cables were in working order. But since the report was issued there had been a breakdown in the St. Vincent-Barbadoes cable, which was one of their single systems. The colonies were, in consequence, agitating for a duplicate cable, but as it was an unremunerative line, owing to the conditions under which it was put down, the Company had pointed out that unless there was a modification of those conditions, they could not invest more money in an unremunerative undertaking. They were quite ready to meet the colonies half way. After stating that there was nothing in the accounts to call for remarks, the Chairman concluded with a reference to the death of Mr. W. Abbott, especially to his connection with this Company.

Mr. Morton said the report did not give the figures for the year, but he would do so. Their earnings in 1887 were £91,949; but the interest on investments did not figure in the report. They brought the receipts up to £96,297. The entire expenses, including interest on debentures, was £45,870 for the year. He calculated that this was sufficient to pay the interest on the preference shares, and leave 5s. on the ordinary shares. This being the case, he was surprised shareholders were content to sit down and receive nothing. The fact was, like the boys of Dotheboy's Hall, they had had all the life ground out of them by ill-usage. They were in a splendid commercial position, and yet were reaping no advantage as shareholders. They were earning 5s. on each ordinary share, and yet the shares were selling at 2s. in the £. They had a reserve fund of £130,000, and £10,000 in addition. Yet because of the arrears of interest, which amounted to £53,000, the ordinary shareholders were getting nothing. The matter might easily be put upon a fair basis in a few months by getting a short Act of Parliament passed. Why should it not be done? If the arrears were paid off, then £10 shares would be selling for £5, instead of a miserable 2s. in the pound. He could afford to wait, but there were hundreds of small shareholders who could not. There was no need to wait for an improvement of business. They were already in a state of prosperity; and, if the Directors would adopt this policy, they would make the Company a commercial success, instead of one of the greatest failures ever known. If they were too poor, why did they pay 2,000 guineas a year to the Directors in fees? A poor bankrupt company ought not to do it. It was monstrous, and he should not fail to lift his voice up against it until such a state of affairs was removed. He was one of the largest shareholders of the Company, and he should not cease to complain. The shareholders treated the Directors liberally, and ought to be treated liberally in return. He wished to move: "Resolved that until the arrears of dividend on the first and second preference shares are paid off, no further sums be placed to the reserve fund.

The **Chairman**: It is not competent for you to move a resolution of which no notice has been given. It is, besides, a resolution affecting one of the fundamental articles of association.

Mr. Morton: I move it as an amendment to the report. I think I know sufficient of the procedure of company meetings to know I have a right to do so. I protest against its not being received.

The **Chairman** declined to receive the resolution.

Mr. Firth said the question of utilising the reserve fund to pay off the arrears of interest was one for the directors. Inasmuch as they had now an available balance per annum of £17,000, three or four years would suffice to pay off the arrears. They could, therefore, look forward to the future with satisfaction, and might now bury the hatchet. He would like to know, however, if the Directors did not now think the reserve fund large enough.

The **Chairman** urged the absolute necessity of preserving the reserve fund intact. Was it right for a company employing a depreciative plant not to set aside a sum calculated to represent the depreciation of it? That was the crux of the whole question. The Directors calculated that they wanted the reserve fund at about what is was now. But

this time next year they would have to add to it another year's depreciation.

After some further discussion the report was agreed to. Messrs. W. Earle and W. Ford were re-elected Directors.

LONDON-PLATINO BRAZILIAN TELEGRAPH COMPANY.

The tenth ordinary general meeting of the London-Platino Brazilian Telegraph Company, Limited, was held on Tuesday at Winchester-house, Old Broad-street.

Sir John Pender presided, and, in moving the adoption of the report and the declaration of a dividend of 3s. a share, reminded them that at their last ordinary meeting, a year ago, he referred to negotiations that were going on with the Brazilian Government and with the Western and Brazilian Company with a view to the latter taking over the management of the Company's affairs. Those negotiations had terminated, and meetings had been held approving the arrangements which had been come to between the two compani s.

Mr. Francis Pavy seconded the motion, which was agreed to.

The resolution passed at the meeting on the 27th ult., approving the agreement with the Western and Brazi ian Company, was afterwards confirmed.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

At a special general meeting of the Western and Brazilian Telegraph Company, Limited, held on Tuesday, at Winchester House, Old Broad-street, Mr. W. Andrews in the chair, the resolutions passed at the meeting on the 26th ult. were confirmed. They were for making certain alterations in the articles of association of the Company; approving the agreement made with the London Platino-Brazilian Telegraph Company for acquiring that company's undertaking; and for increasing the capital of the Company to £1,500,000 by the creation of 30,090 shares of £15 each, to rank *pari passu* with the existing ordinary shares of the Company.

WOODHOUSE AND RAWSON, LIMITED.

An extraordinary general meeting of the shareholders in Woodhouse and Rawson, Limited, was held on Tuesday at the City Terminus Hotel.

Lieutenant-General Sir John Stokes, who presided, stated—referring to the object of the meeting—that it would have been competent for the Directors to have declared an interim dividend, and to have made a further issue of shares without calling a general meeting, but they had thought it better to act as they had done. They had submitted a balance-sheet, which would show that the Directors' decision as to the interim dividend was justified, and it would enable the shareholders to form an opinion on the position of the Company. The first half-year's working had given them a profit of over 40 per cent. per annum, but the Directors would declare a dividend at the rate of not more than 12 per cent. per annum. They thought it more prudent to carry the remainder—more than £8,000—to the current half-year, especially as it consisted principally of shares in other companies, which were growing in value. Since the formation of the Company they had acquired some valuable patents at a merely nominal price. The actual amount of working capital brought into the business on its being turned into a limited company was only £2,855, the Board having considered it advisable at the formation of the Company to begin with a small capital and gradually to extend the business as they saw fit, the interest paid on advances from the bankers being nominal compared with the profit made. As to the increase of capital now proposed, he might mention that large contracts for lighting, the pushing of patents abroad, and the manufacture of plant at home required them to lie out of their capital for considerable periods. They had now decided on issuing 6,000 of the ordinary shares (on which they proposed to call up by the 1st of July 35s. a share, the same amount as had been called up on the first issue) and £30,000 in 6 per cent. first mortgage debentures of £100 each, on which £15,000 would be paid up by the 1st of July, and the remainder by the end of the year. Important negotiations, which had extended over many months, and which would lead to a large extension of their business, had been brought to a satisfactory conclusion.

In answer to a question, the Chairman stated that at the outset only 14,000 of the shares were placed at the disposal of the public. The issue now proposed was part of the original capital.

PROVISIONAL PATENTS, 1888.

MAY 4.

6657. **Improvements in secondary batteries or electric accumulators.** Benjamin David Williams, Bristol Bank Buildings, Bristol.

6680. **Improvements in electric railways.** George Edward Vaughan, 57, Chancery-lane, Middlesex. (Samuel Trott, Nova Scotia.)

MAY 5.

6740. **An improved portable electric lamp.** James Tarbotton Armstrong and Auguste Serraillier, 8, Quality-court, London, W.C.

MAY 7.

6772. **Improvements in electrical measuring, testing, and other apparatus.** Theodore Calliphronas, 14, Arundel-square, London, N.

MAY 8.

6828. **An instrument to be called the "Automatic telautograph."** Frederick James Tolehard, Bradford Lodge, Paignton.

6834. **An instrument for the measurement of the co-efficients of electro-magnetic induction.** Arthur Prince Chattock, University College, Liverpool.

6836. **An electro-dynamic relay for constant or varying currents.** William Edward Ayrton, John Perry and David Cook, The City and Guilds of London Institute.

6876. **Improvements in apparatus for measuring electric currents.** Hermann Aron, 6, Lord-street, Liverpool.

MAY 9.

6889. **Improvements in dynamos and motors.** Oliver Firth and Edward Wright Crabtree, Sunbridge Chambers, Bradford, Yorkshire.

6893. **Improvements in electro-magnetic and magneto-electric generators.** Edward Cox Walker, Darlington.

6907. **Improvements in storage batteries.** Moritz Immisch, 52, Chancery-lane, London.

6909. **Apparatus for use with dynamo-machines.** Edward John Houghton, 1, Pilkington-road, Peckham, London, S.E.

6910. **A system of electric lighting.** Edward John Houghton, 1 Pilkington-road, Peckham, London, S.E.

6927. **Improvements in electrically propelled vehicles, and appliances connected therewith.** Michael Radcliffe Ward, 55, Chancery-lane, London, W.C.

6928. **Improvements in electric switches.** Frederik Vilhelm Andersen and John Forwood Tafe, 3, Elm-court, Temple, E.C.

6953. **Improvements in electric gas-lighters.** William Southern, 6, Lord-street, Liverpool.

MAY 10.

6985. **Improved switch for electrical tramcars.** Moritz Immisch, 52, Chancery-lane, London.

6988. **Improvements in the method and means of supplying electrically-worked vehicles with fresh sets of accumulators or equivalent sources of electricity.** Michael Radcliffe Ward, 55, Chancery-lane, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MAY 2, 1887.

6400. **Improvements in electro-magnetic apparatus for the automatic lighting and extinguishing of gas lamps.** Johann Rudolf Schiller and Christian Meyer, 115, Cannon-street, London.

MAY 17, 1887.

7189. **Improvements in secondary batteries.** William Hopkin Akester, 57, Chancery-lane, London.

JUNE 7, 1887.

8206. **Apparatus for effecting by insertion of a coin the production of electric light for a certain time.** Dixon Henry Davies and John Mesny Tourtel, 28, Southampton-buildings, Chancery-lane, London, W.C.

JUNE 13, 1887.

8495. **Improvements in electric lamps.** Alexander Melville Clark, 53, Chancery-lane, London. (Camille Berton, France.)

JULY 7, 1887.

9598. **Improvements in electrical apparatus for working railway signals.** Illius Augustus Timmis, 2, Great George-street, Westminster, London, S.W.

MARCH 2, 1888.

3246. **Improved electrical lamp and projector, and method of applying same for maritime and other purposes.** Frederick Walker, 4, Little Moorfields, London, E.C.

MARCH 3, 1888.

3303. **Improved apparatus for registering the consumption of electric energy.** Henry Harington Leigh, 22, Southampton-buildings, Chancery-lane, W.C. (Jean Louis Clerc, Paris.)

APRIL 7, 1888.

5203. **A method of and apparatus for transmitting sounds to a distance by means of light.** Leon Jules Le Pontois, 28, Southampton-buildings, London, W.C.

SPECIFICATIONS PUBLISHED.

1887.

6221. **Governing by electro-chemical action, &c.** A. Shippey and W. J. L. Hamilton. 11d.

6581. **Holders for electric lamps.** E Manville and W. L. Madgen. 8d.

7265. **Phonic reception of electrical signals.** C. Ader. 8d.

9853. **Dynamo-electric machines.** H. Watt. 8d.

16,709. **Electrical generators.** T. A. Edison. 8d.

1888.

633. **Dynamo-electric machines.** C. Coerper. 8d.

734. **Galvanic batteries.** J. Noad. 8d.

3483. **Electrical switches.** F. T. Schmidt. 6d.

3685. **Electrical switches.** S. Sharp and others. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	$3\frac{1}{4}$
12 Feb.	2/0	— fully paid	5	4
15 Feb.	10/0	Anglo-American	100	$38\frac{1}{4}$
15 Feb.	20/0	— Pref.	100	$64\frac{1}{2}$
12 Feb., 85...	5/0	— Def.	100	13
28 Mar.	3/0	Brazilian Submarine.........	10	$12\frac{1}{2}$
16 Nov.	1/0	Con Telephone & Main ...	1	$\frac{3}{4}$
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	$2/2\frac{1}{2}$	Direct Spanish	9	$4\frac{1}{4}$
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	$8\frac{7}{8}$
12 April	2/6	Eastern	10	$11\frac{3}{4}$
12 April	3/0	— 6% Pref.	10	$14\frac{3}{4}$x
1 Feb.	5%	— 5%, 1899	100	107
28 Oct.	4%	— 4% Deb. Stock	100	$107\frac{1}{8}$
12 Jan.	2/6	Eastern Extension, Australasia & China............	10	13
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	$103\frac{3}{4}$
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	$6\frac{1}{8}$x
12 April	2/0	Globe Telegraph Trust......	10	6
12 April	3/0	— 6% Pref.	10	$13\frac{7}{8}$
3 Jan.	5/0	Great Northern...............	10	$14\frac{5}{8}$

Dividend.		Name.	Paid.	Price. Wednesday.
1 Mar	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	$17\frac{3}{8}$
28 Oct.	12/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	6
16 Mar.	5%	Maxim Weston	1	$\frac{1}{8}$
15 May	5%	Oriental Telephone	11	$\frac{7}{16}$
14 Oct.	4/0	Reuter's	8	$8\frac{1}{4}$
......	...	Swan United	$3\frac{1}{2}$	$2\frac{1}{2}$
15 Feb.	$15\frac{1}{2}$%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	$40\frac{1}{8}$
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	$15\frac{1}{8}$
......	...	West African	10	5
1 Mar.	5%	— 5% Debs.	100	$92\frac{1}{2}$
29 Dec.........	6/0	West Coast of America ...	10	$5\frac{3}{4}$
31 Dec.	8%	— 8% Debs.	100	117
14 Oct.	3/9	Western and Brazilian	15	$10\frac{3}{16}$x
14 Oct.	3/9	— Preferred	$7\frac{1}{2}$	$6\frac{5}{8}$
......	...	— Deferred..................	$7\frac{1}{2}$	4x
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	$1\frac{1}{16}$
30 Nov.	...	— 6% 1st Pref.	10	11
13 May, '80...	...	— 6% 2nd Pref.	10	$6\frac{1}{2}$
2 Nov.	7%	West Union of U.S.	$1,000	125
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Mar. ...	£37,331	+£1,376
Brazilian Submarine	W. May 11 ...	£4,312	...	Great Northern	M. of Apl.	21,400	...
Cuba Submarine	M. of Apl. ...	3,700	+ £736	Submarine	None	Published.	
Direct Spanish......................	M. of Feb. ...	1,800	+ 119	West Coast of America	M. of Apl. ...	4,325	...
— United States	None	Published.	...	Western and Brazilian	W. May 11 ...	3,561	...
Eastern..............................	M. of Apl. ...	51,582	+ 8,446	West India and Panama	F. April 30 ...	3,268	+ 231

Abbreviations: W., week ; F., fortnight ; M., month.

CITY NOTES.

Change of Address.—The Electrical Automatic Delivery Box Company, Limited, has taken offices at 45, Eastcheap.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ended May 11 amounted to £4,312.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ended May 11, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,561.

Companies of the Month.—The following electrical companies were registered during the month of April :—

Telephone Union, £5 shares	£10,000,000
Kensington and Knightsbridge Electric Lighting Company, £5 shares	250,000
Tunbridge Wells Electric Light Company, £5 shares	30,000
Protean Battery Syndicate, £10 shares	5,000
Electric Date and Time Stamp Company, £1 shares	100,000
Bournemouth Electricity Company, £5 shares...............	50,000
United Kingdom Telephone Union, £5 shares	10,000,000
Southampton Electric Light and Power Company, £5 shares	30,000

Hastings Electric Light Company.—The following report of Directors will be submitted at the ordinary general meeting, to be held at the Electric Light Works, Earl-street, Hastings, on Tuesday, 22nd day of May, 1888, at four o'clock in the afternoon precisely :—The Directors present herewith their statement of accounts for the year ending 31st March, 1888. The Company is now supplying 30 arc and 864 incandescent lamps, as against 30 arc and 704 incandescent lamps last year, again showing an increasing business. The Directors have every reason to believe that by laying down mains in new directions and increasing the plant, the demand for supply of electric light will enormously increase. The principal hotels are now lighted by electricity with very satisfactory results, and applications are being made to substitute incandescent lighting for gas in places of worship and business establishments. On referring to the profit and loss account it will be seen that the gross profit for the year amounts to £558 18s. 1d., but from this must be deducted interest on overdraft at bankers and on debenture bonds, issued to the amount of £1,000, thus leaving a balance of £314 9s. 4d., out of which the Directors propose paying a dividend of £3 per cent., free of income-tax, amounting to £204 10s., and carrying forward the balance to next year's account. The suggestion of the Directors at the last annual meeting of the shareholders, as to raising a sum of £5,000 by means of debenture bonds, was not carried out, but a sufficient number of shareholders were found willing to take up bonds to the amount of £1,000, bearing interest at 5 per cent. per annum. The Company's bankers, Messrs. Beeching and Co., kindly agreed to reduce the rate of interest on overdraft to £5 per cent. The revenue account shows that a sum of £166. 6s. 3d. has been charged to that account for repairs to boilers, including a new fire box put in by Messrs. Robey and Co., of Lincoln. Messrs. Reeves, Langham, and Woodhams are the retiring Directors, and offer themselves for re-election. The Auditors, Messrs. Hart, Brothers, Tibbetts and Co., retire, and offer themselves for re-election.

Lawrence Light, Heat, and Power Company of London, Limited.—Registered by Ashurst, Morris, Crisp, and Co., 6, Old Jewry, London, E.C. Capital £250,000, divided into 50,000 shares of £5 each. Object: to carry into effect an agreement expressed to be made between the Lawrence Automatic Gas Company, Limited, of the one part, and the Company of the other part; to carry on the business of makers and suppliers of gas or any other illuminants, and manufacturers of and dealers in lighting and heating apparatus and appliances of all kinds. The first subscribers are :—

	Shares.
J. D. Chapman, 64, Wellington-street, Woolwich	1
E. T. Botwright, accountant, 23, Sutton-place, Hackney, E.	1
F. T. Marney, clerk, 12, Bradley-road, Wood Green	1
F. Chapple, solicitor, Claremont-road, Highgate	1
E. S. Harper, accountant, Goodrich-road, East Dulwich...............	1
J. Alexander, accountant, Danby-street, Peckham, S.E.	1
W. C. Horton, 297, Crystal Palace-road, Dulwich	1

The number of Directors shall not be more than seven nor less than three, and the first shall be appointed by the subscribers to the articles of association. The qualification shall be the holding of not less than 50 shares in the capital of the Company. The remuneration shall be fixed by the Company in general meeting.

NOTES.

Madras.—Arrangements are being made to introduce electric motor cars into Madras.

Barnet.—The contract between the Barnet Local Board and Mr. Joel for lighting the town by electricity has been signed and sealed.

Japan. — The Mikado has commissioned a Japanese engineer to visit the States, to gain information with the intention of introducing electric railways into Japan.

Tender.—The London and County Land and Building Company, Limited, are prepared to receive tenders for the electric lighting of their Lombard-street and Drapers'-gardens estates.

Mather Steam Dynamo.—The Mather steam dynamo illustrated last week consists, we are given to understand, simply of Mr. Arthur Riggs' rotary engine, with the addition of the wiring.

Hamburg.—The work of installing the electric light at the free port and docks of Hamburg is actively in progress, and comprises 50 arc lights and about 4,000 16 c.p. incandescent lamps.

Society of Telegraph-Engineers.—The paper to be read at the meeting to be held on Thursday, May 31st, is "On the Influence Machine, from 1788 to 1888," by Prof. Silvanus P. Thompson.

Gas v. Electricity.—An official report says the working expenses in connection with the lighting by electricity of South Kensington Museum amounted to £1,224. Gas would have cost £2,845.

St. Catherine's Lighthouse.—The authorities at Trinity House have superseded the fixed oil light at St. Catherine's lighthouse for a flashing electric light, showing one flash of five seconds' duration every half minute.

Strand.—The question of lighting the streets in the district with electric light was brought up by the Lighting Committee of the Strand district at the meeting last week, but in view of legislation they recommended no steps be taken at present.

Weston-super-Mare.—The Weston-super-Mare Town Commissioners have instructed the Finance Committee to report upon a proposal for the adoption of the electric light. The cost is estimated at £20 per lamp per annum, equal to a rate of 1d. in the £.

Lord Salisbury and Technical Education.—The Marquis of Salisbury has consented to move a resolution in support of the proposed South London Polytechnic Institute, and the necessity for technical education in this country, at a public meeting to be held at the Mansion House on June 8.

Eastbourne.—The directors of the Eastbourne Electric Light Company, having been asked to supply the electric light till a later hour, have decided, during the ensuing summer months, to run their incandescent lamps till 1 a.m. if the consumption is sufficient to warrant the cost of production. A week's trial will be made.

Stealing Lamps.—Denver, Colorado, has its streets lighted with incandescent lamps. It has lately been noticed many of these lamps have been broken or stolen, as many as twenty in one night having been carried off. It is not known whether it is thieves who have done this, or some person wishing to bring discredit on the light company.

Samples of Light.—Mr. W. F. Brown, the agent of the Bernstein Electric Light Company in Minnesota, has hit upon the "brilliant" idea of doing his canvassing with a sample. He takes round a small storage battery capable of running a 40 c.p. lamp for about three hours. This makes a fine display, is very effective, and saves much talk.

House-to-House Supply Company.—For their first central lighting station, at West Brompton, this company has ordered three horizontal coupled compound steam engines from Messrs. John Fowler and Co., three water-tube steam boilers, with water-heaters and feed-pumps, from the Babcock and Wilcox Company, and three sets of alternating current dynamo electric machinery from Elwell-Parker, Limited.

Fire Premiums.—With reference to the recent discussion on fire risks and the reduction of premiums, we notice the New England insurance companies have agreed to make a reduction in their rates for premises lighted entirely by electricity, with liberty to use gas or oil for not more than ten days in any one year in event of accident to the electric light. Our contemporary, the *Gas World*, says the moral is obvious. There seems to be more than one moral!

Westinghouse Meter.—Mr. Otto A. Moses, electrical expert, of New York, has reported upon the new electric meter made by the Westinghouse Company for an alternating current system, and pronounces it a perfect success. It shows the number of hours and candle-light units, and the amount in dollars and cents, so that every man can read and keep his own electricity account. He pronounces it more reliable than any gas meter, and will be largely put in use at once.

Artificial Lightning.—The steam yacht "Warrior," which formerly belonged to Mr. Bailey, of Hull, and is now the property of the Egyptian Government, has been fitted with the electric light at Messrs. Day, Summers, and Co.'s, Northam. She went out for a trial trip on Tuesday, and in the evening a trial was made with the electric light, the flashing with which caused considerable interest in the lower part of the town, a great many in the upper part also mistaking it for lightning, thinking that a storm was coming up.

Electricity is Life.—"Electricity is Life," say the charlatans who announce at immense cost in the current journals the sale of their galvanic belts and rings, magnetic plasters, and other deceptions for the use of devotees. *Electricity is death*, says the Government of New York, who have decreed that condemned criminals shall in future be despatched to Pluto by the means of an electric shock. No doubt this example will be followed in other countries, and here is a new branch created for makers of dynamos.—*L'Electricien.*

Bournemouth.—The Committee of the Improvement Commissioners last week reported that a draft license under the Electric Lighting Act, 1882, was read, and after considerable discussion as to the request of Messrs. Phillips, Harrison and Hart for sanction to their application to the Board of Trade, it was moved that the Committee recommend the Board not to give their sanction at present, on the ground that, though the Board would have to give their sanction eventually, it would not be fair or advisable to give the monopoly to one company at the present time.

Kensington Town Hall.—At the Board meeting on May 16 it was moved that the town hall be lighted by electricity, and that the Special Purposes Committee be requested to advise the vestry as to the tenders referred to in their report (dated April 24th) for running mains and wires for supplying electricity to light the town hall and offices, and for the supply of the necessary fittings. An amendment was moved that the matter be deferred for one year, but was lost. A further amendment was moved on the first motion—"That the matter be deferred for three months." This was carried by 33 to 20.

Political Economy of Motor Cars.—Mr. Hewitt, Mayor of New York, advocates tramcars of rapid transit with a speed approaching that of railways; no construction above the surface can give the solidity necessary, therefore he favours an underground plan. Rapid transit by tramcars, he says, will enable us to derive the benefit of increased taxation on outlying districts, for property increases as the square of the velocity of travel. He would have the corporation construct subways, useful also for mains, pipes, wires, &c., and rent them to various companies using them. The enormous expenses of laying down conduits and of taking up the streets perpetually would thus be saved.

Testing for Ores by Telephone.—An interesting application of the sensitiveness of the telephone to currents of weak but varying strength is that of an apparatus patented by Mr. John R. Williamson, Seattle, Washington, for testing rocks for ore, which may probably prove of great utility in mining operations. One pole of a battery is connected by a flexible wire to a wire brush, which can be lightly brushed over the ore to be tested. The other pole is connected to a telephone in the ordinary way, and to a metal plate on which the ore is placed, if a specimen, or to earth if *in situ*. If the rocks contain metal, the contact of the small portions with the brushes complete the circuit, and a scratching sound is heard in the telephone. When no metallic ore is present, no sound is heard.

Nickel Plating.—A new process of nickel plating has recently come into use in Belgium, by which a thick plating of nickel may be deposited on any metal by a feeble electric current in a very short space of time. The bath is composed of 10 parts sulphate of nickel, 7½ of neutral tartrate of ammonia, 0·5 parts tannic acid, and 20 parts of water. The sulphate of nickel is dissolved in three to four parts of water, carefully neutralised, the other ingredients added, and the solution boiled for a quarter of an hour; the rest of the water is added, and the liquid filtered or decanted. By adding the materials in the same proportion, the strength of the bath may be kept constant. It is said that the deposit is brilliantly white, soft, and homogeneous, and has, even when of great thickness, no tendency to scale.

Single Wire System.—The offices of the *Scotsman* newspaper, in Edinburgh, are lighted throughout with incandescent lamps on the single wire, or earth return, system, on which we published a paper recently. The installation consists of about 370 lamps of 16, 32, and 50 c.p., supplied by two 300 light dynamos: in conjunction there is also a battery of 110 accumulator cells, capable of feeding 200 lamps. The positive wire in all cases is insulated, and the switches and fuses are placed on this wire. The return wire is connected to the metal work of the fittings. Main switches and fuses control each department, and a switch is provided to each fitted. The installation was carried out under the superintendence of Mr. J. D. F. Andrews, of the firm of Muir, Mavor and Coulson, Glasgow.

Finsbury Technical College.—The annual *conversazione* of the students of the Finsbury Technical College will be held to-night at seven o'clock. Prof. Silvanus Thompson will give a lecture on the "Polarisation of Light," and Prof. Perry on "Magnifying Springs." A concert will be held during the evening, and there will be an exhibition of scientific apparatus. Tickets may be obtained at the College, Leonard Street, E.C. The next meeting of the Old Students' Association will take place at the Finsbury College, on Tuesday, May 29, at 7:30 p.m., when Mr. Reginald J. Jones, A.S.T.E., will read a paper on "Some Installation Breakdowns" This will deal with all aspects of the question of breakdowns in electric machinery, arc and incandescent dynamos, gearing, motors, circuits, arc and incandescent lamps, fuses, &c.

Birmingham.—A project is now on foot to light a portion of the central part of the business premises of Birmingham. The authorities of the Old Library, Union-street, consulted Messrs. Chamberlain and Hookham on the question of lighting the Library, and it was found necessary to obtain premises for machinery outside. To justify this expense other persons near were asked to join, and the scheme has become quite a central installation. Messrs. Chamberlain and Hookam have marked out a district bounded by High-street, New-street, Corporation-street, to Union-street. This district can be conveniently lighted from a central station, provided the consumers will give their consent to have the distributing wires fixed to their premises. It is proposed to supply the light by meter on terms similar to those at Liverpool, where a private central station lighting is under sanction of the Town Council and Board of Trade.

Admiralty.—The Engine-room Telegraph Committee, which have been sitting at Portsmouth for more than a year, have now prepared their report. As a consequence of their experiments and deliberations, it has been determined to fit the whole of the ships of the Admiral class with electric, in addition to the usual mechanical, telegraphs for communicating between the bridge and the engine-room. As the ventilation of the dynamo flats in these ships is so bad that it is well nigh impossible for the men to live in them for any length of time, it has also been resolved to provide them with peace fittings in the shape of additional dynamos. These will be placed on the main deck and will be of 100-ampere power. In time of war the service dynamos, which are below the water-line and are protected from shot, will be used for the search lights and glow lamps. Another innovation is to be introduced whereby four projectors will be fixed in each of the Nordenfeldt projections at the corners of the superstructure deck, so that in case of an expected torpedo attack the ships will be able to surround themselves with radial beams of light.

Queenstown.—At the meeting of the Queenstown Town Commissioners on Wednesday the subject of electric lighting was brought before them by Mr. Carbery, who stated that when recently in London he had inquired into the subject of electrically lighting the town, and had come to the conclusion that if the commissioners undertook to supply the light to the shopkeepers, they would be able to do so, and, from the income received, get the town lighting free. We have carefully read the report of this meeting as given in the *Cork Daily Herald*, and feel convinced that Mr. Carbery must have misinterpreted the information given to him. His estimate seems to be founded on an arc lighting system solely, with overhead wires, and not sufficient attention has

been given to the incandescent lighting for the interior. At any rate it was decided to advertise only in the *Freeman's Journal*, the *General Advertiser*, and *Investors' Guardian* for tenders. It may be that many of our readers will consult the columns of these papers, otherwise we fear the Queenstown authorities will not have much difficulty in comparing the tenders.

Electric Lighting in Luxemburg.—The houses in the little village of Hesperange, near Luxemburg, the first station on the Mondorf and Remich Steam Tramway, are lighted by incandescent electric lamps, maintained by a dynamo worked off a flour mill engine. In this way the light does not become expensive, but has the disadvantage of being intermittent according to the exigences of the mill. The Steam Tramway Company, too, complains of induction to its telephone wire through the propinquity of the lighting leads, so that, now the Hesperangers have got used to the electric light, it is probable they will have an independent installation. The village of Rosport, and the town of Echternach are also electrically lighted by Mr. Henry Tudor. The latter place is provided with from five to six hundred incandescents of 6, 8, 10, 16, 25, and 35 c.p. besides a 1,000 c.p. and two 500 c.p. arcs in the old Basilica. These are maintained by a Schuckert and a Spiecker dynamo, driven by a 16-c.p. horizontal engine by the Gebruder Pfeiffer, which is run from 8 to 11 p.m., after which current is supplied by accumulators. A sum of 3fr., or half-a-crown is charged for a 10 c.p. lamp per 100 hours. The installation was started on 1st November last year.

American Institute of Electrical Engineers.—The general meeting for the reading and discussion of professional papers was held on Wednesday, May 16th, and the following papers read: "On a new system of Alternate Current Motors and Transformers," by Mr. Nikola Tesla. "The Possibilities and Limitations of Chemical Generators of Electricity," by Mr. Francis B. Crocker. "Underground Electrical Systems in Europe and America," by Prof. G. W. Plympton, of the Brooklyn Subway Board. "On Compensated Resistance Standards," and "On Prof. Moler's 'Swinging Arm' Galvanometer," by Prof. Edward L. Nichols, of Cornell University. "The Patent Court and Uniformity in Patent Practice," by Mr. George H. Stockbridge. "Protection of the Human Body from Dangerous Currents," by Mr. P. B. Delaney. Mr. Emile Berliner, of Washington, member of the Institute, has devised an apparatus which he calls a "molecularium," and by means of which, adopting the theory of molecular vibration, he explains and illustrates a large variety of electrical phenomena, including those connected with static charge and discharge, voltaic current, heat, &c. Mr. Berliner has presented to the institute a model of this apparatus, which was exhibited at the meeting.

Telegraphing from Trains.—The fact that all the other telegraph lines were down during the late blizzard in America, and that the train-telegraph line remained entirely intact, was due to the method of construction on the Lehigh Valley Railroad, the plan being to use only stout wooden poles, firmly and strongly set in the ground, with no cross arms, and carrying a single wire. No storm could break down wires thus fixed, for what test could be severer than the late blizzard? If, then, this is so, why do not the railway and telegraph companies realise the utility of this method of fixing for at least part of the wires independently of the advantage of communicating to trains? With regard to the latter question, the advantages are evident on the surface. One who was blocked in a train in a snowstorm, and kept for hours without possibility of communicating with the outside world, asks with reason, Why do not the railroads appreciate at once the enormous advantages of this system, and the great convenience and comfort it would be to their passengers, and also a source of profit as well to the railway company having the sagacity, foresight, and enterprise to adopt this wonderful and extremely practical system of telegraphing from trains? Many would gladly give sums of five shillings or a pound for the chance of communicating during a block by telegraph with anxious friends and families.

Coast Telegraphy.—Mr. Bayley, writing to the *Times* on the Earl of Onslow's Bill to give Lloyd's power to purchase land for signal stations, and thus improve the electrical communication on our coasts, gives the following information as to what Denmark has done in this direction. He says: We have only to go to Denmark to find that electrical communication of the best kind has been provided by the Government on the west coast of Jutland, and, in the Kattegat, telephone lines are laid to the lifeboat and rocket stations, which connect them with the inland telegraph stations. The telephone stations are served by the man or woman who may be on the station, and they are allowed to charge about 3½d. for each message or telegram sent off. For those received no charge is made. The lines are laid chiefly in the interests of the fishermen, and, as they serve both lifeboat and telephone stations, they use them very freely among themselves for market purposes, as well as in case of shipwreck and for private information. In the year 1887 the following messages were received and sent from the telephone stations:—Received from Denmark, 2,560 messages; received from abroad, 619 messages; sent off to Denmark, 3,162 messages; sent off to abroad, 1,314 messages; 1,807 communications were also held between the various stations. At the Skaw, Hirtshalls, and the Hirtsholm lighthouses the keepers act as telegraph clerks. They advise the Copenhagen exchange of all ships that signal as they pass, and report information about weather, wind, shipwrecks, &c., to those who desire to know.

Leamington.—The Tramway Company at Leamington asked permission of the Town Council to experiment with an electric tramcar. This was given subject to the approval of the town clerk, who was to see that no injury was done to the roadway.—At a stormy meeting in which the electric light at Leamington was freely discussed, Councillor Crowther Davies moved that twelve months' notice be given to the company to terminate the arrangement. That the company were supplying shops and private individuals with light satisfactorily, he was well aware. He stigmatised the street lighting as in the highest degree unsatisfactory—"A yellow incandescent wire flickering in a finger-glass at the end of a gibbet—hardly equal to those sold at a shilling a box, known as Price's patent night lights." He said there were as many as eleven lights out on one night, and that they were not more than 8 c.p. Councillor Mansfield sympathised with the company, who had been experimenting with their own money, but still he regarded the electric light as a dismal failure. Still, he would not support the motion, as he should like the company to have an opportunity of offering the town something better than they had at present. Others thought that the light was neither a success nor a failure; that it was better

than the old system, but not what they wished to see; that the company should have fair play, as they had already spent £30,000. The Mayor considered the light had been a success, and, that after the company had spent so much money, it would be most unfair to carry such a resolution. On the vote being taken, there were 10 in its favour and 10 against it, and the matter remains *in statu quo*.

The Telephone.—The following letter is from the *Sunderland Daily Herald*, May 16: "Sir,—I should like to call your attention to a very objectionable custom that promises to convert the telephone into a positive nuisance. The custom referred to, which must have proved a great annoyance to all who have had occasion to visit offices using the telephone, is as follows: If you are conversing with a gentleman on any subject, no matter how important, and the telephone bell rings, he abruptly leaves you and flies to the instrument as though it were his master and he its servant, or rather its slave. I do not know whether it is the novelty of the affair, so that we must regard it as a case of a child and new toy, but at all events such is the custom; the gentleman leaves you, though you may be in the middle of a sentence, and you are doomed to that eternal one-sided business: 'Are you there?' 'Five pounds per ton.' 'No.' 'Yes,' 'Yes,' 'Yes, but I think oil's better,' and so forth. When all is over your polite (?) gentleman, without apology, resumes the conversation with you. Now, let us see what all this means. It means simply this, that you take the trouble to go from your office to see a gentleman, whilst my lord impatience at the other end of the wire does not. You get possession of the child who has the toy, and you are entitled to keep him against all comers till done with him. Indeed, everyone waiting in the ante-room when the bell rings is entitled to precedence as against the individual who takes his ease at the other end of the wire. Nay, I will even go further, and contend that everyone who arrives before the distant telephonist could have reached the ante-room ought to come before him. Now, whilst the practice is its infancy, is the time to teach these gentry manners, or it may get too strong for resistance. Those who have the power should distinctly decline to be made a convenience of for the benefit of anyone who, though he may be able to afford the telephone, is not on that account entitled to sit in his office and, into the bargain, gain an unfair advantage over those who have taken the trouble to make a journey. If the custom does not amount to rudeness and impudence, it 'sails very close to the wind.' What on earth is there in the telephone to give such precedence?—Yours obediently, VICTIM."

British Association.—The 58th annual meeting of this association will take place at Bath, beginning Wednesday, September 5; the President will be Sir Frederick J. Bramwell, D.C.L., F.R.S., M.Inst.C.E. The section most interesting to electrical engineers will be those of:—A.—*Mathematical and Physical Science.*—President, Prof. G. F. Fitzgerald, M.A., F.R.S.; vice-presidents, Captain Abney, R.E., F.R.S., F.R.A.S., F.C.S., William Esson, M.A., F.R.S., F.R.A.S., F.C.S.; secretaries, R. E. Baynes, M.A. (recorder), R. T. Glazebrook, M.A., F.R.S., Prof. H. Lamb, M.A., F.R.S., W. N. Shaw, M.A. B.—*Chemical Science.*—President, Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.; vice-presidents, Prof. Odling, M.B., F.R.S., V.P.C.S., W. H. Perkin, Ph.D., F.R.S., V.P.C.S.; secretaries, Prof. H. B. Dixon, M.A., F.R.S., F.C.S., H. Forster Morley, M.A., D.Sc., F.C.S. (recorder), R. E. Moyle, B.A., F.C.S., Dr. W. W. J. Nicol, M.A., F.R.S.E. G.—*Mechanical Science.*—President, W. H. Preece, F.R.S., M. Inst. C.E.; vice-presidents, W. Anderson, M.Inst.C., W. Shelford, M.Inst.C.E; secretaries, C. W. Cooke, W. Bayley Marshall, E. Rigg, M.A. (recorder). H.—*Anthropology.*—President, Lieutenant-General Pitt-Rivers, D.C.L., F.R.S., F.G.S., F.S.A.; vice-presidents, J. Beddoe, M.D., F.R.S., J. Evans, D.C.L., LL.D., Treas.R.S., F.S.A., F.L.S., F.G.S.; secretaries, G. W. Bloxam, M A., F.L.S. (Recorder), J. G. Garson, M.D., F.Z.S., M.A.I. The first general meeting will be held on Wednesday, September 5, at 8 p.m. precisely, when Sir H. E. Roscoe, M.P., D.C.L., LL.D., Ph.D., F.R.S., F.C.S., will resign the chair, and Sir F. J. Bramwell, D.C.L., F.R.S., M.Inst.C.E., president-elect, will assume the presidency, and deliver an address. On Thursday evening, September 6, at 8 p.m., a *soirée*; on Friday evening, September 7, at 8:30 p.m., a discourse on "The Electrical Transmission of Power," by Prof. W. E. Ayrton, F.R.S.; on Monday evening, September 10, at 8:30 p.m., a discourse on "The Foundation Stones of the Earth's Crust," by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S.; on Tuesday evening, September 11, at 8 p.m., a *soirée*; on Wednesday, September 12, the concluding general meeting will be held at 2:30 p.m. Excursions to places of interest in the neighbourhood of Bath will be made on the afternoon of Saturday, September 8, and on Thursday, September 13.

Curiosities of Lightning.—Mr. J. D. Dougall, writing to the *Times* from Glasgow on this subject, says:—"Saturday's thunderstorm in the North seems to have been exceptionally heavy. From most reliable private information I learn that at Glasgow 'the air seemed full of forked lightning,' this lightning being incessant, from the remarkable fact that there were two separate storms going on simultaneously, one on the one side of the city, and the other on the other side. The lightning is described as 'something terrible.' It may interest scientists and others to learn that the three boys struck by the lightning on Glasgow-green, as reported in your yesterday's issue, were neither walking nor standing up, but sitting in a row on the grass, and a most respectable person, from whom I have the information almost directly, saw the whole three simultaneously fall over on being struck, and, strange to say, the boy in the middle shortly afterwards sit up again, the other two being killed. That he should survive while the outsiders were killed seems remarkable, and the case may come to be recorded among the many curiosities or eccentricities of lightning strokes. It may be somewhat out of place, after giving the particulars of so sad an accident, to narrate the following; but I do so solely as bearing on the influence of thunderstorms on the lower animals, and not as affecting the gentle sport of angling. Many years ago I was fishing in a tributary of the Cart, Lanarkshire—viz., the Kittock, a brook famous for the large size of its trout, running up to several pounds in weight, and out of all proportion to its small volume of water. I had only seen a few small trout until about 1 o'clock, when a heavy thunderstorm came on, and all at once large fish seemed to rush forth from their hiding places and to feed greedily. I well recollect the lightning gleaming on their yellow sides as they dashed wildly at my flies, so wildly, in fact, as to cause them to miss their aim. I had, however, taken several good fish, when a message was sent from an adjacent farmhouse, imploring me so earnestly to come in out of the storm or I should assuredly be killed, that I could not well refuse, and so an incident unique in my own experience, and such as

I have never heard of in that of others, was cut short. Salmon are known to move and feed during sudden squalls of wind and atmospheric disturbances, but for trout of more than usual shyness, like those in the Kittock, to be moved by a violent thunderstorm seems opposed to all general or popular ideas.

Bath.—At a meeting of the Bath Town Council on Tuesday, the recently-appointed Electric Lighting Committee brought up their report, which consisted merely of a printed tabulated statement, containing a summary of the information the committee had obtained from places where the electric light is or has been in use. The cost in all cases but that of Waterford, where it was the same as gas, was considerably above that of gas; and all the towns gave an unqualified negative to the question, "Do you find the electric works a nuisance?" In presenting this information, the committee stated that they now waited further instructions. The chairman (Mr. Sturges) moved that the Council instruct the committee to obtain tenders for lighting a central area by electricity, and to report such tenders to the Council. He exhibited a diagram of the district it was proposed to light on the new system. At present this district had 273 gas lamps of 20 c.p. each, nine of 100 c.p. each, and four of 80 c.p. each; and it was proposed to substitute for these lamps seventy electric lights. The seventy electric lamps would give a total of 84,000 c.p., or, taking one-third off for obscuration of the light by the ground-glass globes, a net illumination of 56,000 c.p. The illuminating power of the existing lamps was 6,860 candles, so that the electric system would give something like nine times more light. As for the cost, the present cost for lighting the district mentioned was £953 annually, and though the electric light experts originally thought the new system would cost £1,400, Mr. Massingham now assured him he did not believe it would cost more than £300 in excess of the present amount, or about one-third additional. There were several reasons why the cost of the electric light in Bath would be less than elsewhere. The coal requisite could be obtained very cheaply, as Bath stood on the borders of a coal country; there was considerable water power available at the town weirs; and the old slaughter-house site would be a good position for the works. Mr. Sturges then expatiated upon the merits of the electric light, and concluded by observing that his resolution bound the Council to nothing, but only enabled them to ascertain what could be done, how it could be done, and how it could be best done. Several of the leading citizens were willing, if necessary, to form a local company for supplying the light at the lowest possible cost of production. An amendment was moved to add to the resolution the following clause, "And that the committee invite the gas company to tender for supplying a better light than they did at present." Several members thought that if the Gas Company would supply gas of 30 c.p it would be as great an advantage to the citizens as the introduction of the electric light. Major-General Burn said he should be very sorry to find the question of gas introduced into the resolution, for not only did he look upon the electric as a much better illuminant than gas, but also as being safer for the city. If they had their streets lit with it they would get it introduced into the theatre, hospital, and other public buildings. Several members thought that even if the Gas Company could be induced to raise the illuminating standard of the gas supply to 30 c.p. it would still be unable to compete with electricity, and fail to satisfy the requirements of the citizens. On the amendment being put only six voted for it. The resolution to advertise for tenders for electric lighting was then put and carried unanimously.

Mather and Platt's Dynamos.—Messrs. Mather and Platt, Salford, who have a recognised reputation for supplying the highest class of dynamos and electric machinery, have just issued a second edition of their catalogue of "Edison-Hopkinson" and "Manchester" dynamos. The "Edison-Hopkinson" dynamo, therein illustrated in its different sizes and types, is guaranteed to give a commercial efficiency of 90 to 94 per cent. (according to size), a result, they claim, higher than any other make in the world. The type giving 320 amperes, 110 volts, at 780 revolutions, was tested with the following results: commercial efficiency 93·23 per cent., loss in core 1·94, in magnets 1·66, in armature 3·17 per cent. The efficiency of the same dynamo used as a motor is 93·79; on the double conversion 87·05 per cent., without loss in leads. The smallness of the loss internally, together with the great care in mechanical details, gives this dynamo great advantages in durability, and a continuous run of three weeks, with an excess of 10 per cent. over its normal load, has been effected with these machines. The great distinction of this dynamo is the extreme intensity of its magnetic field, a feature which enables the machine to be self-regulating within ordinary limits without compound winding. Not the least advantage is complete absence of sparking at the brushes, the commutator showing little wear for years, and the brushes lasting, with care, for a twelvemonth or longer. Each machine has two sets of brushes, so that one set can be adjusted or removed without disturbing the current. A recent improvement introduced into some sizes of the Edison-Hopkinson dynamo is the construction of the armature with copper bars, instead of insulated wire. By this means the amount of copper in a given size of armature is largely increased and the resistance diminished, which enables a larger current to be carried with the same economy. The bar armature has the further advantage, that at no point of the armature do two bars, on which the electric pressure is widely different, come into close proximity, which much diminishes the possibility of a cross or breakdown of insulation ever occurring, should the dynamo not receive proper attention, or be subject to very sudden variations of load. Messrs. Mather and Platt's second type of dynamo—the "Manchester" dynamo—is remarkable, not for any distinctive departure in construction, but for a happy conjunction of all the best-known electrical and mechanical principles of dynamo construction, being small, very compact, and efficient. In some of the larger sizes the efficiency is over 93 per cent. These machines are all compound-wound for incandescent lighting, in sizes from 20 to 350 lamps. They are also supplied series-wound for arc lighting. The armature is wound so that no parts of widely different pressure are in close proximity. These dynamos are also used as motors, with a commercial efficiency of 90 per cent. A series of trials, communicated to the Royal Society, showed that the double conversion of h.p. over 100 yards was effected with a total efficiency of 77·5 per cent. At the Manchester Jubilee Exhibition, a calico-printing machine, requiring 20 h.p., was driven by a "Manchester" dynamo, working as a motor, during the whole exhibition. A combined engine and dynamo is also supplied, with short belt and special belt-tightening pulley gear, for use in confined spaces or on board ship. Special dynamos for testing and teaching purposes are made with special switchboard for altering to series, shunt, or compound-wound arrangement.

ARTISTIC FITTINGS.

I.—Laing, Wharton, and Down.

In our issue of March 9 was given a paper on "Artistic Electric Lighting," which carried a moral to the effect that not only is it necessary to consider such things as volts and amperes, but the cultivation of the beautiful and, generally, artistic effect must not be lost sight of. Our competitors of the gas interests have long paid great attention to the visible fittings of their work, and the effects produced are often pleasing to the eye and effective in the *mise en scene.*

Fig. 1.—Table Lamp with Shade.

The ordinary gas fittings can hardly be classed among the beautiful, and when success is spoken of it refers only to those instances when special designs have been made to agree with the general architecture of the room. When the incandescent electric light was first introduced many thought and argued that no change would be required

Fig. 2.—Double Table Lamp.

in the fittings, and that the old stock of gas fittings might be used up. It is not so. The electric light lends itself to a far greater variety in the matter of fittings than does gas, in that the flame of the latter must necessarily be in all ordinary cases upwards, while the incandescent filament can be placed in any direction required to give a particular effect. This was soon seen, and a few firms commenced to make a speciality in electric fittings. A large number of beautiful designs have been produced, many examples of which are before us. It is almost impossible to adequately illustrate such designs in black and white, and no doubt an early attempt must be made by means of colours. Still, for the moment, a general idea may be given. Recently visiting Messrs. Laing, Wharton, and

Fig. 3.—Electrolier.

Down's new show-rooms, in New Bond-street, we were shown a large number of fittings specially designed for electric light purposes. These fittings are all made by hand, of mixed materials—hammered copper and brass—

Fig. 4.—Wall Lamps.

very highly and carefully finished, and so great attention is given to the lacquering and polishing that no cleaning is required. From among a number of designs we have selected the following:—

Fig. 1 shows an elegant table lamp, carrying a shade of silk of any colour. Of course, it is easy to arrange for the contacts in these table lamps, either by means of flexible

wires, or, if the lamp is ordinarily required in one particular place, by means of a conducting contact through the table.

Fig. 2 shows another design of table lamp, with branching arms for two lamps. It will easily be understood that these various table lamps are designed for various purposes—some for the dining-room table, some for the drawing-room, some for card tables, reading desks, and so on, through the requirements of the house.

Fig. 3 shows a light electrolier for a moderately-sized room. It is generally believed that it is the design of such electroliers which permits the greatest display of artistic taste, though some unbelievers maintain the contrary, and that the greatest difficulty of the designer is met with when he has to design a solitary lamp fitting, and keep the cost down to a minimum. Still, we allow that business men have to consider what pays best, and undoubtedly they have a greater latitude allowed them when making a large electrolier than with the single fitting. It must not be taken that we look upon any of these fittings as costly; they are not, and we are inclined to believe that the cost compared with the cost of gas fittings will always be in favour of the electric light.

Fig. 4 shows two examples of wall fittings, such as might well serve in a bed-room or a smoke-room.

ELECTRICAL TRAMWAY IN HAMBURG.*

BY J. L. HUBER.

Many efforts have been made of late years to adopt electricity for working tramways. Overhead and underground conductors have been, and are still, employed; but the difficulty is to find a substitute for horse-power in the crowded streets of large towns, where overhead conductors are not admissible, and where those laid underground are exposed to a multiplicity of evils only known to those who have endeavoured to cope with them. In this field the storage-battery alone could compete with horse-power, and then only when the energy is stored in a properly controllable form. The author ventures to say that every practical engineer, knowing the conditions which exist in large towns, will agree with him that any vehicle destined principally for the transport of passengers should be, when possible, independent and self-contained in its motive-power. It is unadvisable to depend upon an engine located at a distance, a breakdown in which, or defects in the leads, would interrupt the service of the whole line. These views influenced him in choosing the Julien system for introduction into Hamburg. A paper read before the Society of Arts by Captain Douglas Galton, on the 20th of January, 1886, fully describes the Julien system.† The speciality of the system is that accumulators, in which the energy is stored, are used in different groups, which may be placed in parallel or in series, according to the power required. This is accomplished by a special switch under the control of the driver, and without any artificial resistance. Only one electric motor is necessary, the power from which is transmitted by ropes to a counter-shaft, and from this by a pitch-chain to one of the axles.‡ The first car (No. 61) in use at Hamburg is similar to that exhibited at Antwerp in 1885. The weight of this car is, ready for service, 4·83 (metric) tons, of which the accumulators come to 1·2 ton, and the weight of the series-wound motor of Messrs. Siemens Brothers, London, to 572lb. The accumulator-battery is placed in eight drawers, with slide contacts; in each drawer there are four boxes, with three cells, and with 15 plates in each cell, consequently there are 96 cells. The whole battery is divided into four parts of 24 cells each; these four parts may be arranged, by simply turning the Julien switch, either (1) all four in parallel, giving a current of $24 \times 2 = 48$ volts tension; or (2) two and two parallel, and then in tension = 96 volts; or (3) two in parallel behind the two others, in tension = 144 volts; and (4) all four in tension = 192 volts. The capacity of each cell is 92 ampere-hours, and consequently the amount of stored-up energy is $192 \times 92 = 17{,}664$ watt-hours. The tram-way-line selected for the trials with the electrical traction extends from the Rathhausmarkt in Hamburg to the Berthastrasse in Barmbeck, and is 5,360 metres (5,862yds.) long. The steepest incline on the line is 1 in 40 and 100 metres long, but only about 800 metres are level, the remainder being more or less steep inclines with numerous curves. Thus this line, of which the route for nearly two miles lies through crowded streets, presents all the difficulties which tramways have to overcome in large towns, and as the trial has been extended over eight months (May to December, 1886) on a common public road, it may be considered a very fair one. During the whole of the trial the engineer in charge recorded the number of watt-hours charged on each battery, to find when it needed re-charging, and the time and length of way which the car had run with the battery before this became necessary. By always putting fully-charged batteries into the cars, the amount of watt-hours put into the accumulators, to replenish them, after having done a certain service, gave a full account of the work done. It showed the energy required for the work, and the variations between the different loads, or the difference of power required to run the car. Before commencing the regular service, the author made trial trips at night with the car No. 61 from the Berthastrasse to the Rathhausmarkt and back. During these trial trips the car was loaded with iron bars, to represent the full weight with passengers in regular service. The current passed through one of Paterson and Cooper's ampere-meters; the revolutions of the motors were indicated by a tachometer of Buss and Sombart, and the tension of the current was controlled by one of Paterson and Cooper's voltmeters. The weight of the car was, on all the trial trips, 7 tons, of which 4·83 tons represented the weight of the car proper, and the remainder that of 29 passengers, one driver, and one conductor, or 31 persons at 154lb. each. The result was that in running up the main inclines 10,700 watts were used—*i.e.*, 54 amperes at 192 volts; further, that on the level 1,800 watts—namely, 19 amperes, multiplied by 96 volts—were required, and that the dynamo made then 900 revolutions. The ratio between the dynamo and the driving-axle was 1 to 10, the diameter of the wheels being 736 millimetres (29in.), and the circumference 91in. Thus, at 900 revolutions of the motor, the speed of the car was—

$$\frac{900 \times 2{\cdot}312}{10} = 208{\cdot}080 \text{ metres,}$$

or about $3\frac{1}{3}$ metres in one second = 12 kilometres ($7\frac{1}{2}$ miles) in one hour. The speed allowed for the tramcars is 12 kilometres an hour in the town and 16 kilometres in the suburbs. As the trial trips were made during the night, the author drove the car at a higher speed. As tractive power he calculated 12 kilogrammes for every ton of weight, plus 1 kilogramme for every millimetre of grade per metre, and per 1 metre of speed per second, or—

$$T = \{(t \times 10) + (t \times g)\}\, s,$$

where T is the tractive power, t the weight in tons of 1,000 kilogrammes, g the grade in millimetres per metre, and s the speed in metres per second. This formula gives very fair results when the rails are in good condition; but to allow for curves, as well as for dirty rails, it is necessary to multiply the values given by the formula by 1·5. The journey from the Berthastrasse to the Rathhausmarkt and back to the Berthastrasse, equal approximately to 11 kilometres (6·8 miles), occupied 55 minutes, and $96{,}802 + 94{,}652 = 191{,}454$ watt-minutes were indicated, or 3,481 watts per minute, or 17,405 watt-minutes = 290 watt-hours for every kilometre. As during the trial the accumulators were in first-rate condition, an efficiency of 80 per cent. could be reckoned on, and thus the accumulators required a charge of 362 watt-hours for every kilometre of way made by the car (7,000 kilos) on the line in question.

As stated above, the output of the accumulators was 17,664 watt-hours, and thus, in every 290 watt-hours per kilometre, 60 kilometres might be run with one load; but as at any moment something might occur on a tramway, and more power might be required to overcome it, the author did not consider it advisable to allow the accumulator to run so far down; and besides, the life of accumulators is

* Selected Paper, Institute of Civil Engineers' Proceedings.

† *Journal* of the Society of Arts, vol. xxxiv., p. 157.

‡ *Elektrotechnische Zeitschrift*, Berlin, 1887, p. 222; and *Zeitschrift des Vereins Deutscher Ingenieure*, 1887, p. 332 and Plate 9.

prolonged when they are never fully discharged. . . . The mean energy expended in volt-amperes to reload the accumulator was:—In July, 392·16; August, 354·72; September, 441·49; October, 417·87; November, 701·92; and December, 561·374. The lowest amount of energy for 1 kilometre employed in one day, when only one car (No. 61) was running, was 280 watt-hours, on the 23rd of August; and the highest to the end of October 630 watt-hours. This enormous difference, as well as the daily variations, were due to the state of the rails and the traffic, which were both influenced by the weather. During summer, and in fine weather, the rails are clean, and in Hamburg the streets are well swept and watered; besides, the traffic is small, and the public evenly distributed on both platforms; but if the weather is misty the rails are slippery, the cars more fully occupied, and the passengers avoid the forward platform and crowd on the hind one. This, when the driven axle is foremost, occasions loss of

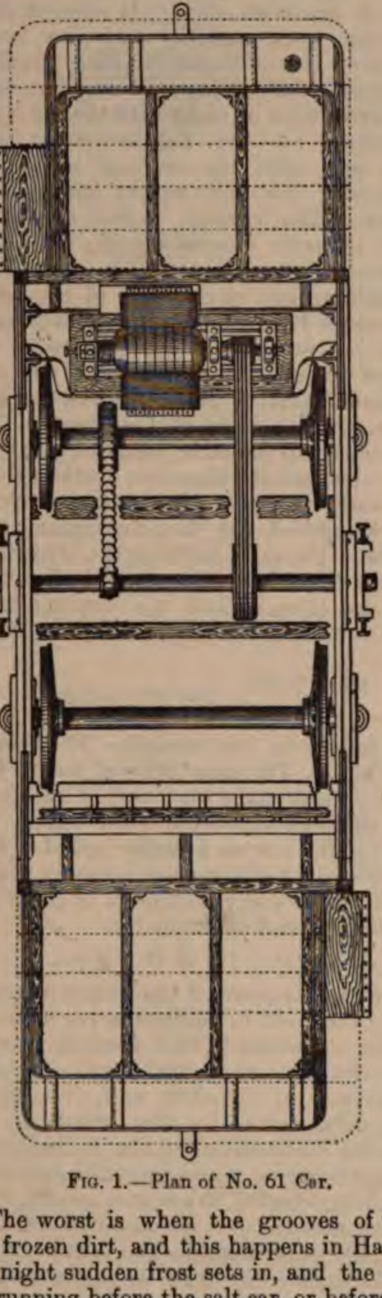


FIG. 1.—Plan of No. 61 Car.

energy. The worst is when the grooves of the rails are filled with frozen dirt, and this happens in Hamburg when during the night sudden frost sets in, and the cars have to commence running before the salt-car, or before the salt has sufficiently acted; such a day was the 8th of December, when the average energy rose to 890 watt-hours.

Now, with an average of 362 watt-hours per one kilometre, 19 amperes at 96 volts are employed on the level, and 54 amperes at 192 volts on different inclines, so that there must be, when 630 watt-hours are necessary, an expenditure of at least $\frac{54 \times 630}{362} = 94$ amperes on the inclines; and it is probable that, under bad conditions of the road on the inclines, the power will be still higher than under good conditions, and that a current of over 100 amperes will pass the motor.

An electric current of 94 amperes × 192 volts is equal to an expenditure of $24\frac{1}{2}$ h.p., which had been taken out of the accumulators; but this had not been used only as tractive power, for it had heated the motor and had been wasted, and this is the weak point of all electric tramways. Every locomotive and every self-propelling car is made to do a certain amount of work on a certain line, to propel at a certain speed a limited weight on a maximum of incline that is, at a maximum of resistance of the road; if the weight is constant, and the resistance on the road increased, the speed diminishes, and at last the motor must stand still. In a steam engine the amount of steam, or energy, that might be taken out of the boiler (the accumulator) depends

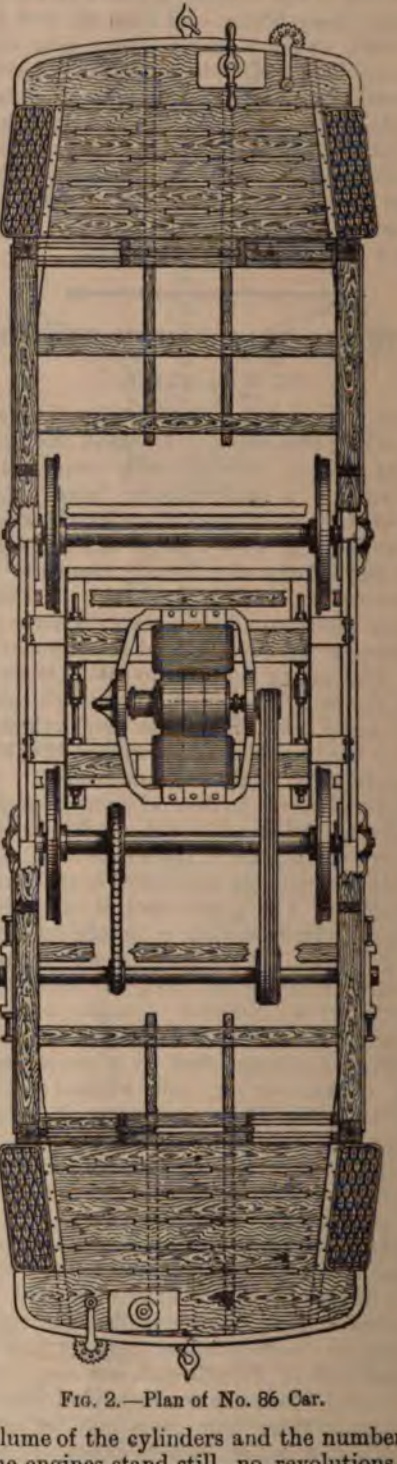


FIG. 2.—Plan of No. 86 Car.

upon the volume of the cylinders and the number of revolutions. If the engines stand still, no revolutions are made and no steam is taken out of the boilers; and if the safety valves do not blow off steam, no energy is wasted. Quite different are the conditions of the electric motor; the amount of current that flows through the coils of the motor (for tramcars series-wound motors are to be considered) depends upon the number of revolutions of the armature; and, at the same tension of the current, the greater the number of revolutions the less is the amount of current Thus, when by increased resistance on the road the speed of the vehicle, and consequently of the motor (armature),

diminishes, the amount of current increases, and comes to its maximum, which depends upon the internal resistance of the motor when the motor stands still. Every motor is constructed to run at a certain tension of the current, at a certain speed, and will then take a certain amount of current. If, by overloading the car, or overcharging the motor, the speed diminishes, the amount of current will increase, yet the increase of current will perform very little useful work, but heat the motor. The heat partly disappears by radiation, but is, at all events, a waste of energy, and must be avoided.

The appearance of heat or light where only power is needed is a waste of energy, and consequently a waste of money. Still, this occurs in a great number of electrical installation, and principally electrical tramways; in these installations a series of artificial resistances are employed, and are more or less thrown into the circuit, according to the amount of current that has to pass the motor to attain a certain speed or to start. Then, as in those installations, the tension of the current is constant, the amount of current that flows through the motor depends only upon the resistance in the leads to be overcome. Then resistances do not act only like a throttle-valve, but they get heated, and this heat must be absorbed by radiation by the surrounding air, otherwise they will melt. In experiments made for this purpose, the author has melted glass tubes 15 millimetres (0·59in.) in diameter and 500 millimetres (19·68in.) long, which he had surrounded with a spiral of German silver wire 1·2 millimetre (0·05in.) in diameter, and imbedded in infusorial earth in a porcelain pipe of the same length, and of 25 millimetres (0·98in.) outside diameter. The spiral was melted and stopped the experiment, which he repeated several times, varying the tension of the current, and therefore the amount of amperes passing, and consequently the time in which the wire melted. These experiments show what amount of heat or energy is wasted by resistances placed in the current, and that it is wasteful to adopt such means to use up less energy in the motor; it would be like employing a brake to regulate a steam-engine, instead of cutting off and expanding the steam; the resistances in an electric current will do there, because they are simple, where a small amount of current passes them, or where the loss of energy is negligible. To avoid the resistances, Mr. Julien has grouped the accumulators in parallel or in series, as most convenient, and this constitutes one of the great advantages of using accumulators instead of direct current; then by direct current the tension is always constant, and must be so high as to do the maximum of work required on the line, to ascend inclines, or to run with full load at a certain speed. Where this maximum of work is not required, resistances must be introduced. Since, as above shown, the use of the common resistance spirals is wasteful, the author recommends, instead of them, accumulators, which, when charged by the necessary surplus of energy in the line, will serve to light the train or otherwise, and so avoid the useless waste of energy. Finally, the amount of power required on different parts of the line may vary very much; but as it is not necessary to ascend steep inclines at the maximum of speed, the motor or motors may be arranged in such a way that they can do, at a limited speed, the required maximum of work without getting hot, and to effect this the author proposes the use of two motors instead of one, combined in such a way that one may suffice for the level, or for small inclines, but that the two may be placed in parallel on steep inclines; using, then, the current at half tension, the motors will turn at the lower speed, corresponding at this lower tension, and thus the car will run at lower speed, and require less power to ascend the inclines. The simplest way to arrive at this "relay" for common tramcars would be to place two armatures on the same shaft in the same, or in two different magnetic fields. But the two motors should not be placed on two different bogies, as in that case a car would always be liable to run off the rails on sharp curves; the forward motor would, on entering a curve, be relatively the weaker one, as it has to overcome more resistance than the one behind, and would be easily thrown by the latter off the rails. This is so well known to railway engineers, that he would not have mentioned it had he not seen an electric car arranged in this way.

After the first car, No. 61, had been in use some time, the author arranged a second car, No. 86, for electrical traction. This car was fitted in a similar way, but the motor was placed between the two axles, and the car had seats for 20 passengers inside; its weight was, ready for service, 6 metric tons, and when loaded with 30 passengers, one driver and one guard, 8·24 tons; the weight of the accumulators was 1·94 ton, and of the motor, 1,188lb. The motor was by Messrs. Elwell and Parker, and similar to those used on the Blackpool electric tramway. A great advantage of these motors is that instead of using two pairs of brushes, only one pair of contacts is employed to bring the current to the collector of the armature. It is thus possible in running down hill to use the motor as a dynamo, driven by the mechanical energy developed, and charge the accumulators. But further, the motor itself serves as a powerful brake, and he has so employed it many times, when it is necessary suddenly to bring the car nearly to a standstill to avert damage or accident. The final result of his trials is that to drive a tramcar on a line, for every 220lb. of weight and 1,000 metres (1,093 yards) of way, 7·8 watt-hours are required.

M. D'ARSONVAL ON DANGEROUS CURRENTS.

It may be interesting to give the following abstract of a paper presented by M. D'Arsonval to the Academy of Sciences relating to experiments with various generators of electricity. He used (1) a Holtz machine to charge a Leyden jar; (2) a battery with E.M.F. of 420 volts; (3) a Gramme direct-current machine; (4) Gramme alternate-current machine; and (5) induction coils. Electricity is stated to produce death in two ways—(*a*) directly by injury to the tissues; (*b*) indirectly by action on the nerves. In the former case life is beyond recall; in the latter, it is in most cases possible to bring the individual back to life by artificial respiration instantly resorted to. A static discharge is not absolutely mortal, unless the "medulla oblongata" be struck by a localised discharge, the energy of which exceeds 22 foot-pounds. In that case the tissues are destroyed. With weaker discharges, the effect is due to excitement of the nervous centres, or, more tardily, to secondary results of injury. It is much less easy than is generally believed to kill an animal outright by a discharge of frictional electricity. M. d'Arsonval concludes that the duration of discharge is of the greatest importance; and, in alternating currents, the frequency of alternation. In the general case of accident death occurs through reflex action, and mostly through arrested respiration; and the practical conclusion is that in every case artificial respiration should be instantly resorted to.

ON THE HEATING EFFECTS OF ELECTRIC CURRENTS.*

BY W. H. PREECE, F.R.S.

I have taken a great deal of pains to verify the dimen sions of the currents as detailed in my paper read on December 22nd, 1887, required to fuse different wires of such thicknesses that the law

$$c = a\, d^{3/2}$$

is strictly followed; and I submit the following as the final values of the constant "*a*" for the different metals:—

	Inches.	Centimetres.	Millimetres.
Copper	10,244	2,530	88·0
Aluminium	7,585	1,873	59·2
Platinum	5,172	1,277	40·4
German silver	5,230	1,292	40·8
Platinoid	4,750	1,173	37·1
Iron	3,148	777·4	24·6
Tin	1,642	405·5	12·8
Alloy (lead and tin 2 to 1)	1,318	325·5	10·3
Lead	1,379	340·6	10·8

With these constants I have calculated the two following tables, which I hope will be found of some use and value:—

* Read before the Royal Society on April 19th, 1888.

TABLE SHOWING THE CURRENT IN AMPERES REQUIRED TO FUSE WIRES OF VARIOUS SIZES AND MATERIALS.

$$c = a\, d^{3/2}.$$

No. S.W.G.	Diameter. Inches.	$d^{3/2}$.	Copper. $a = 10,244$.	Aluminium. $a = 7,585$.	Platinum. $a = 5,172$.	Ger. Silver. $a = 5,230$.	Platinoid. $a = 4,750$.	Iron. $a = 3,148$.	Tin. $a = 1,642$.	Tin-lead alloy. $a = 1,318$.	Lead. $a = 1,379$.
14	0·080	0·022627	231·8	171·6	117·0	118·3	107·5	71·22	37·15	29·82	31·20
16	0·064	0·016191	165·8	122·8	83·73	84·68	76·90	50·96	26·58	21·34	22·32
18	0·048	0·010516	107·7	79·75	54·37	54·99	49·95	33·10	17·27	13·86	14·50
20	0·036	0·006831	69·97	51·81	35·33	35·72	32·44	21·50	11·22	9·002	9·419
22	0·028	0·004685	48·00	35·53	24·23	24·50	22·25	14·75	7·692	6·175	6·461
24	0·022	0·003263	33·43	24·75	16·88	17·06	15·50	10·27	5·357	4·300	4·499
26	0·018	0·002415	24·74	18·32	12·49	12·63	11·47	7·602	3·965	3·183	3·330
28	0·0148	0·001801	18·44	13·66	9·311	9·416	8·552	5·667	2·956	2·373	2·483
30	0·0124	0·001381	14·15	10·47	7·142	7·222	6·559	4·347	2·267	1·820	1·904
32	0·0108	0·001122	11·50	8·512	5·805	5·870	5·330	3·533	1·843	1·479	1·548

TABLE GIVING THE DIAMETERS OF WIRES OF VARIOUS MATERIALS WHICH WILL BE FUSED BY A CURRENT OF GIVEN STRENGTH.

$$d = \left(\frac{c}{a}\right)^{2/3}$$

Current in amperes.	Diameter in Inches.								
	Copper. $a = 10,244$.	Aluminium. $a = 7,585$.	Platinum. $a = 5,172$.	German Silver. $a = 5,230$.	Platinoid. $a = 4,750$.	Iron. $a = 3,148$.	Tin. $a = 1,642$.	Tin-lead alloy. $a = 1,318$.	Lead. $a = 1,379$.
1	0·0021	0·0026	0·0033	0·0033	0·0035	0·0047	0·0072	0·0083	0·0081
2	0·0034	0·0041	0·0053	0·0053	0·0056	0·0074	0·0113	0·0132	0·0128
3	0·0044	0·0054	0·0070	0·0069	0·0074	0·0097	0·0149	0·0173	0·0168
4	0·0053	0·0065	0·0084	0·0084	0·0089	0·0117	0·0181	0·0210	0·0203
5	0·0062	0·0076	0·0098	0·0097	0·0104	0·0136	0·0210	0·0243	0·0236
10	0·0098	0·0120	0·0155	0·0154	0·0164	0·0216	0·0334	0·0386	0·0375
15	0·0129	0·0158	0·0203	0·0202	0·0215	0·0283	0·0437	0·0506	0·0491
20	0·0156	0·0191	0·0246	0·0245	0·0261	0·0343	0·0529	0·0613	0·0595
25	0·0181	0·0222	0·0286	0·0284	0·0303	0·0298	0·0614	0·0711	0·0690
30	0·0205	0·0250	0·0323	0·0320	0·0342	0·0450	0·0694	0·0803	0·0779
35	0·0227	0·0277	0·0358	0·0356	0·0379	0·0498	0·0769	0·0890	0·0864
40	0·0248	0·0303	0·0391	0·0388	0·0414	0·0545	0·0840	0·0973	0·0944
45	0·0268	0·0328	0·0423	0·0420	0·0448	0·0589	0·0909	0·1052	0·1021
50	0·0288	0·0352	0·0454	0·0450	0·0480	0·0632	0·0975	0·1129	0·1095
60	0·0325	0·0397	0·0513	0·0509	0·0542	0·0714	0·1101	0·1275	0·1237
70	0·0360	0·0440	0·0568	0·0564	0·0601	0·0791	0·1220	0·1413	0.1371
80	0·0394	0·0481	0·0621	0·0616	0·0657	0·0864	0·1334	0·1544	0.1499
90	0·0426	0·0520	0·0672	0·0667	0·0711	0·0935	0·1443	0·1671	0·1621
100	0·0457	0·0558	0·0720	0·0715	0·0762	0·1003	0·1548	0·1792	0·1739
120	0·0516	0·0630	0·0814	0·0808	0·0861	0·1133	0·1748	0·2024	0·1964
140	0·0572	0·0698	0·0902	0·0895	0·0954	0·1255	0·1937	0·2243	0·2176
160	0·0625	0·0763	0·0986	0·0978	0·1043	0·1372	0·2118	0·2452	0·2379
180	0·0676	0·0826	0·1066	0·1058	0·1128	0·1484	0·2291	0·2652	0·2573
200	0·0725	0·0886	0·1144	0·1135	0·1210	0·1592	0·2457	0·2845	0·2760
225	0·0784	0·0958	0·1237	0·1228	0·1309	0·1722	0·2658	0·3077	0·2986
250	0·0841	0·1028	0·1327	0·1317	0·1404	0·1848	0·2851	0·3301	0·3203
275	0·0897	0·1095	0·1414	0·1404	0·1497	0·1969	0·3038	0·3518	0·3413
300	0·0950	0·1161	0·1498	0·1487	0·1586	0·2086	0·3220	0·3728	0·3617

CORRESPONDENCE.

NOMS DES PLUME.

To THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I had not the pleasure of hearing Mr. Preece's recent paper read at the Society of Telegraph-Engineers—(are we not the Institute of Electrical Engineers yet?)—but I should like to say a few words upon a portion of your leader bearing thereon. If Mr. Preece proposed to taboo *noms des plume*, in my humble opinion he was quite right. I will not go so far as to say that there are no cases where a man would be justified in writing over a *nom de plume*, but I think they are very few and very far between.

In the vast majority of cases, the fact that the writer could not, or would not, allow his name to appear, should be sufficient reason for not writing.

Mere shyness at seeing one's name in print soon wears off, but, on the other hand, the cover of the *nom de plume* is too often used for violent personal attacks and slipshod work. It does not matter, no one will know who wrote it. Even with men who are not given to journalistic discourtesies, the responsibility attaching to the publication of the name of the author, whether of article or letter, must have a sobering effect. It has the same effect that, in my opinion, the admission of ladies to our meetings would have: it tones down the bitterness of many a wordy battle.

I would say, also, that articles should be signed, as well as letters. You are quite right in your remarks as to the education afforded by the technical press. It supplements one's own experience by the thoughts or observations of other men; but if its lessons are anonymous, they lose half their power. One curious result, too, that is not infrequent should make users of *noms des plume* careful—viz., it sometimes happens that two writers of totally opposite views take the same name.

Let each writer have the courage of his opinions; or, if he fears to exhibit them to the world under their true parentage, not exhibit them at all.—Yours, &c.,

SYDNEY F. WALKER.

May 19, 1888.

[The difficulty of signing one's name does not arise in many cases such as those that would probably come under our correspondent's observation, nor, indeed, in many cases where pure, or even applied, science is concerned. Adverse criticism, however, does bring down considerable vituperation upon the head of the critic, and would undoubtedly, at times, subject him to personal insult. A case to the point arises out of the very issue in which we more or less jokingly opposed Mr. Preece. The remarks in the next article were somewhat adverse to a report upon a tramway system, and these, or some other remarks which we fail to recognise, have brought to us some choice "Billingsgate." A copy of the paper with "unsigned" comments, personal and otherwise, scattered over its pages, has been returned to us, postage paid. The writer of these comments evidently has not the courage of his opinions, otherwise the result would have been, had it occurred a century ago,

"pistols for two, coffee for one"—occurring now would lead to avoidance of personal contact as derogatory to any respectable person's reputation.—Ed. *E. E.*]

WIND MOTORS.

To the Editor of The Electrical Engineer.

Sir,—I am interested in wind motors, and the article in your last suggests the following questions:—

The writer asserts that wind motors are economical, but will he give a reason why they are surely and rapidly being superseded for grinding corn in England and elsewhere. Is wind less constant here than in America? Wind mills are almost valueless in this country, as owners have found to their cost.

Now that steam can be generated so cheaply and is always at command, will any one rely upon so fickle or so expensive (for repairs) power as the wind.—Yours, &c.,

Wind Motor.

Colchester, May 19th, 1888.

TAVENER'S COULOMB METER.

To the Editor of The Electrical Engineer.

Sir,—Observing in the current issue of your journal a notice of an electrical meter, said to be of Prof. Elihu Thomson's design, I think that attention should be called to the fact that the principle upon which this meter works has already been adopted by Tavener in his meter. The principle involved is that of utilising the heating property of the current for producing an oscillating motion of the containing-tube, and consequent registration of the quantity of electricity, whether by continuous or alternating currents, passing through the circuit.

As Prof. Thomson's meter has been designed on exactly similar lines as Tavener's, and, moreover, bears upon it evidence of a knowledge of the prior existence of Tavener's meter, it appears to me that to the last-named individual is due the credit for the ingenuity manifested in the production of a meter working on a principle so different from those upon which current-meters have hitherto been designed and worked.

Honour to whom honour is due. To originate a meter working on the principle I have described, which shall register accurately the exact amount of current passing through it at any time, is one thing, but to copy such a meter and appropriate its invention is quite another.—Yours, &c.,

Wm. Phillips Mendham.

Western Electrical Works, Bristol, May 22nd, 1888.

JARMAN'S ELECTRIC TRAM-CAR.

To the Editor of the Electrical Engineer.

Sir,—I notice that you have printed Messrs. E. Walker and Hyde's report upon my electric tram car. So far so good. If you had allowed your readers to have drawn their own opinions, I should not have troubled you with a word of reply, but your remarks thereon, "to my mind," are so unbecoming that I must state what I think upon them. You there state that "one section of the reading public, etc., looks to the technical press for guidance." This I will venture to say they *never* do. The investing public look to that which will bring a good return for their money, and in this particular the technical press is completely impotent, especially in matters electrical. The opinions of high scientific authorities upon the Faure accumulator, etc., etc., a few years since, taught the public generally what value to put upon such. You further state that "Reports of the kind we notice are obtained *only* with the ulterior object either to get money upon patents, or to promote a company." Now I will, like you, stake my reputation upon the fact that this statement is *absolutely* false, and that you are not warranted in making such a statement, because you cannot support one word of it by facts. The truth is, the whole of the working out of this car has been borne by private enterprise for a year and a half. Neither the public nor anyone else have ever been asked to bear a single penny of the expense. Now that the car bears out such favourable results, and considering that before long one of the suburban tram lines will be worked entirely by these cars, goes a long way to prove the unsoundness of your surmise.

I nevertheless adhere firmly to the plan of duplicating the armatures, for reasons which you, apparently, up to the present do not seem to grasp. I think your remarks also ought to be taken, as, you state, about Prof. Short's paper, *cum grano salis*, very much so, as you appear to advocate a certain make of motor, as though other makers would not gladly undertake the same.

It would be very interesting to know of the number of armatures that have been burned out in tram-car experiments where the single armature alone has been employed, this latter defect having led me to construct the present form of motor; and I will further state that, until practice proves my plan to be wrong, I shall firmly adhere to it, considering, as I do, that an ounce of practice is worth infinitely more that any number of unsupported editorial remarks.—Yours, &c.,

A. J. Jarman.

Brixton, S.W., May 23rd, 1888.

[We are glad to find that Mr. Jarman has the courage of his opinions. As we differ entirely upon almost every point touched upon by his letter, and as time alone is required to prove which of the twain is correct, there is little good to be gained by controversy. It may be remarked, however, that time has already shown the technical press to be a powerful factor in the question of electrical investment. Undoubtedly, it does not, and it cannot, stem the torrent when madness seizes the political press; but, in ordinary times, company-mongers electrical are not certain to have their own way when the technical press is against them. We welcome, also, with considerable pleasure, the statement that Mr. Jarman's system has been financed privately, and trust we may find that it will continue to be so financed. If it is as good a thing as its author declares, those who trust it will reap their reward If it turns out badly, they will have the consolation to know they did not lead maids, wives, and widows astray in their investments. *Nous verrons.*—Ed. *E.E.*]

To the Editor of The Electrical Engineer.

Sir,—The report on Jarman's electric tramcar, published in your issue of last week, is, as pointed out in your leader, very unsatisfactory and incomplete. Some four or five years ago Mr. Reckenzaun showed that a tramcar might be propelled along a track by means of a motor and accumulators, and what beyond this can be deduced from the figures furnished in the report? The two most important items—the cost of haulage per car mile and the proportion of dead weight to passenger weight—are conspicuous by their absence. If these were furnished, together with some idea as to how often the battery-plates must be renewed, the report might then be perused with some interest. After what we have seen at Brussels, and still more recently at Stratford, it would be very surprising—even were a charging station for a *large* number of cars laid down—if "there were a distinct saving per car mile over the present cost of maintaining a number of horses to perform the same work," or, indeed, if the figure came out anywhere under 9d. per car mile. From what I have seen of electric tramway work the duplicating of the motor seems to me wholly unnecessary and absurd, and the report itself points to the same conclusion, for on the "return journey" we see that car mounted a gradient of one in twenty, and a little lower down we find "both armatures were perfectly cool." Now, if the motor started and dragged this heavy load up a gradient of one in twenty, and then was perfectly cool, it is quite certain that the heating of its armature will never be such as to cause the slightest inconvenience.

Whatever the purpose served by the report, there is no disguising the fact that the repeated trials and failures of the accumulator cars are having a bad effect on the public, and will cause the various tramway companies to view with apprehension and distrust all further attempts at electrical traction, whether employing accumulators or worked on the direct system, which to many seems to give more promise for the future.—Yours, &c.,

F. C. Allsop.

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S

ANSWER TO CORRESPONDENT.

W. D.—Your letter has been partly answered by post, but as others may desire information concerning the opening for electrical engineers, we give a greater publicity to that portion of the answer. There is far too general an idea that electrical engineering is a genteel profession, and that a man can get on well in it without soiling his hands. This is a mistake. Electrical engineering is but a branch of mechanical engineering, and the best men are those who have an electrical training superposed upon a mechanical training. Roughly speaking, the openings into the profession may be classified under four heads. In addition there are the directors, managers, and the clerical staff, in all of which a commercial rather than a technical training is requisite. We might have also included the estimating department. Take first the designing and the drawing offices. Whatever can be said as to the technical requirements of designers and draughtsmen of other machines can be said with as great force in electrical work. Secondly, we have the testing department. It is herein that the highest technical training tells. The number, however, of vacancies is certainly limited, and when vacant are filled by the best men available. Next we have the artisans—really mechanical engineers—who construct the machines. Then, lastly, we come to those who carry out installation work. These men have diverse duties. Many are merely linemen, earning little more than labourer's wage. Many are labourers purely and simply. Still every installation requires at least one or two men who have a fairly high training. These men are in charge and should have a good technical training, both as regards mechanical and electrical engineering. Just as an engine driver is expected to be able to carry out any little ordinary repair to keep his engine in working order, so the man in charge should be able to do, or direct how to be done, any little operation required to keep the installation thoroughly efficient. We look upon this class of the profession as having in their hands the making or the marring of the future of electrical engineering. The man who knows a lot about curves and formulæ, and book-learning generally, is not worth a dump if he cannot handle a hammer, screwdriver, or soldering iron, and is afraid to tackle any difficulty out of which he cannot see his way with mathematical accuracy. The would-be worker must, therefore, decide into which of these divisions he wants to gravitate and educate himself accordingly.

CONTROL AND REGULATION.

General Webber, during the discussion on Mr. Crompton's paper last week at the Society of Arts, forcibly directed attention to a subject which has not received the consideration it ought. He pointed out that at the present time the electric lighting industry has to contend both against control on the one hand and no control on the other. A company or a firm obtaining a provisional order rests under the disability of being compelled to carry its wires underground, while, on the other hand, the company that ignores provisional orders and desires "to carry electricity to the most profitable points, just as the bee goes from flower to flower in which there is most honey," can and does place the wires overhead without any control whatever. Parliament, General Webber contended, did not intend that the industry should be crippled in an unforseen way of that kind, and the sooner these overhead wires were controlled the better.

The facts of the case are exceedingly simple. Anybody who likes can put wires overhead for any purpose whatsoever, provided permission is obtained from the householder to erect supports. The wires are not restricted to telegraphy or to telephony, nor is it necessary that the one should be above the other; all may be mixed in the manner best calculated to bring about accidents. It is only when a contractor says he intends to satisfactorily provide for a general demand that control comes in, and then he is completely controlled out of existence. Ours is a wonderful nation—wonderfully governed. Good, sound, practical, common sense legislation is so con-

spicuous that it is only recognised by its absence. A telephone company is permitted to do as it pleases, while the electric light company has to comply with the regulations. Both are formed to supply certain wants of civilisation, and both desire to make money for their shareholders. The want supplied by the one is more of a necessity than that supplied by the other, and yet the latter is preferred to the former. Thus it is that those engaged in electric lighting hardly rest easy in their position. Our friends of the gas industry say we clamour too loudly, and yet we only ask that an injustice may be rectified. Generosity is not to be expected in business matters, and especially when competitors are concerned, but it might be well that justice and nothing but justice should be allowed.

The following evening, in his reply at the Society of Telegraph-Engineers, Mr. Crompton mentioned another "regulation" urgently needed, if electric lighting is to increase and multiply. It was the regulation of the various pipes carried under the streets and pathways of this huge metropolis. It seems also that the crowns of the cellars are not all the same distance under the path, and that in some cases there is barely two inches of clearance. There can hardly be any valid reason why the crowns of the cellars should not all be regulated, and not allowed within one foot of the ordinary level of the pathway. The pipes from the gas and water mains into the houses should be placed at regular distances below the surface, then any workman taking up the pathway or street would know where to expect to meet these pipes. Less damage would be done than now, when any blow with the pick may come into contact with a pipe at any distance below the surface. We have always contended that the true solution of the whole problem was in the compulsory construction of subways under every new street laid out. The local authority, upon whom the first cost of construction fell, would charge a moderate sum to users sufficient to repay the initial cost within a term of years, say twenty-five, to provide besides the sinking fund, the annual interest, and a surplus sufficient to keep the subway in efficient repair. The uses to which such a subway could be put are manifold. The gas and water pipes, the telegraph, telephone and electric light wires, would all find a suitable home therein. Difficulties, no doubt, would arise as regards induction, insulation, leakage, &c., but these are not insurmountable and would be overcome. Unfortunately, this devoutly to be wished for consummation is not likely to be carried out by this generation. It is the ideal to which we constantly look. The cost of such a system to the users would, at any rate, not be more than the cost of the present system, when one day the gas company takes up and puts down the roadway, and a week later the water company does similarly. In the course of a few years the money spent in doing this work would build the finest subway ever constructed: and yet we wait for it in vain.

TRACTION.

An American contemporary, seeing the strides electricity was taking for traction purposes on tramways, has set about collecting the opinions of the leading men upon the question of the best mode of traction. The replies are various; nor is there any great preponderance of opinion in any one particular direction. The horse has its advocates, so has steam, while supporters are found for electricity, either supplied direct or by means of accumulators. The President of the Chicago City Railway says: "When an electric motor will draw trains of three or four cars, carrying two hundred people at intervals of forty seconds, for fifteen hours in the day, year in and year out, starting from the very heart of the city and ending away out in the country, in heat or cold, wet or dry, snow or dust, for eleven and one-third cents per car per mile, at the rate of ten to fourteen miles an hour, then, and not till then, can it even claim to approach the cable system as a motive power." The President of the Dallas and Oak Railway says: "I think it will be many generations before steam will be surpassed as a motive power"; while the President of the Oakland Railway inclines to storage batteries, as does the President of the Concord Company. In most cases the opinion given is in favour of that system with which the writer is most interested, though this is not always the case, and we are glad to see some consideration shown towards the living motor, the horse. It is so well known that the strain upon these animals is so great when used for tramway or omnibus work, that they depreciate in value very rapidly. Depend upon it, the animals would not choose that particular class of work if they had any voice in the matter; but although civilisation talks largely about its sensitiveness against cruelty, very little has been done to put a stop to such cruelty. Why not say what is really meant—that the only question which usually arises is that connected with £. s. d.? Unless electric traction, all things considered, becomes cheaper than horse flesh, it will not be used.

THE TESLA SYSTEM OF DISTRIBUTION AND ELECTRIC MOTORS FOR ALTERNATING CURRENTS.

Six patents, says the *Electrical Review* of New York, were issued last week under date of May 1st to Nickola Tesla, involving the various features of his very remarkable system of distribution and transmission of power by alternating currents, which are at the same time adapted for the production of light. The system is based upon a novel principle, which is very clearly set forth in the claim of one of the patents—namely, producing a continuously progressive rotation of the polarities of either or both elements (the

armature or field magnet or magnet) of a motor, by developing alternating currents in independent circuits, including the magnetising coils of either or both elements; and as a modification of this, shifting the poles of one element by alternating currents while magnetising the other element by direct or continuous current.

One of the most interesting forms shows a generator of alternating currents whose armature contains two independent circuits of varying phase, and these two circuits are connected with the field-magnet coils of the motor in such manner that the alternating impulses in these two circuits will produce a continuous rotary shifting of the poles of the field-magnet and communicate a rotary effort to the armature, which in itself is a body of iron with coils of wire, whose circuit is entirely closed. That is, there is no communication whatever of the armature circuit with any other

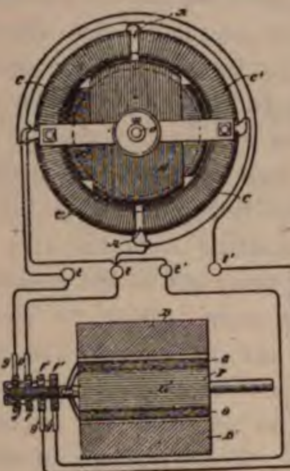


FIG. 1.

circuit, and consequently there is no commutator, collector, or brushes of any kind carried by the armature. It will thus be seen that there is here developed a curious and interesting phase in the construction and operation of electric motors, and one which is entirely novel, in that there is no portion of the entire motor subject to wear and tear in even the slightest degree, except the shaft and its bearings. The direct consequence of this in the commercial use of motors is of great importance, as the attendant having charge of an electric motor of this character would have no more responsibility than he would have in looking after the lubrication of a counter-shaft.

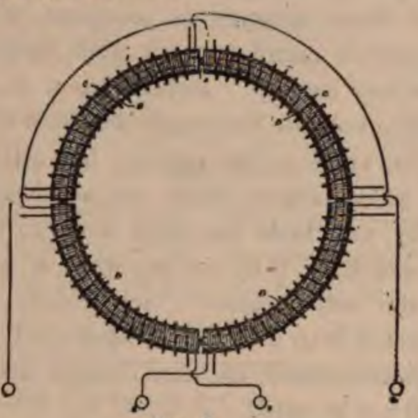


FIG. 2.

Another interesting feature is the result of perfect synchronism between the motor and generator which arises from the peculiar principle of operation of the motor, and the latter can be constructed to run at a predetermined speed provided the speed of the generator and that of the motor have a common divisor. The practical result of this is perfectly constant speed in the motor with constant potential supply, no matter how much the load may vary on the motor. The motor when running at its highest attainable speed reverses almost instantaneously, on a reversal of the line connections, so that the simple motion of the switch effects the instantaneous reversal of the direction, and the time occupied in changing from highest speed in one direction to highest speed in the opposite direction is but a fraction of a second. The rotary effort of the armature is very great, and there is no difficulty whatever attendant upon the starting of the motor under load. The efficiency is extremely high, and can be increased to the highest possible extent attainable by continuous current motors.

The system also takes with it the novel construction and operation of transformers, a simple form of which is illustrated by Fig. 2, which shows a closed magnetic circuit wound with four primary coils which are connected into two high-tension circuits in such manner as to produce two consequent poles at opposite ends of a diameter, and these by the action of the generated current in the high-tension circuits progressively shifting around the magnetic circuit, carrying the consequent poles continuously around; in other words, the two consequent poles rotate continuously, the winding, of course, remaining stationary. The secondary coils are wound on the primaries, and can be connected among themselves in any desired manner, according to the work to be performed.

It will be observed, therefore, that the action of the alternating currents is not to reverse polarities of the core, but to simply rotate them by the peculiar action of the current impulses in the two primary circuits, and it seems to follow, as a matter of course, that there is less energy wasted in the conversion than occurs in the ordinary converter, where the magnetic poles are alternately reversed. Instead of using four wires from the generator three can be used, and one of the three forming a common return for the other two.

Altogether, Mr. Tesla is to be congratulated, not alone on having produced something entirely novel in the electrical world, but also for having made thoroughly practicable the utilisation of alternate currents for the transmission of power. The motors for a given output of mechanical energy are extremely small, and are, as stated, absolutely self-regulating, and there is no electrical element of wear and tear connected with them in any manner whatever, and this feature alone of the closed circuit armature without external connections stamps the series of inventions as being something entirely new and original, and it looks as though the new principle would have great influence on the application of alternating currents to practical forms of electric motors, and we congratulate Mr. Tesla upon his success in this direction.

THE RELATION OF ELECTRIC LIGHTING TO FIRE INSURANCE.*

BY S. E. BARTON.

In considering the relation between electric light and fire insurance interests, I must confine myself mainly to the situation in New England, because I am familiar with what has been and is now being done there, and I am quite as unfamiliar, except in a general way, with the relations that exist between the two interests outside of that small but lively quarter of our country.

In order that you who live away from New England may better understand what I may say as I proceed, it will be well for me to tell you briefly what kind of an insurance organisation we have there.

The New England Insurance Exchange, which exercises a modest control over a part of the fire insurance matters within that territory, with the exception of the city of Boston and State of New Hampshire, is a body composed of the special agents, adjusters, travelling men, or so-called field men, representing the various stock fire insurance companies doing business there—some 150 in number. These men mostly have their headquarters in Boston, which is verily a "Hub" in that respect. They are constantly skirmishing over the territory, individually or in squads of two or more, adjusting losses, and occasionally, through the co-operation of their local agents in the towns and cities, stealing good risks from each other or from some other competitor; but every Saturday finds a large majority of them back in Boston, where they con-

* Paper read before the Pittsburgh Electric Light Convention.

vene in regular session, and consider with legislative dignity any matters of common interest, electric lights included. They swap experiences, swap yarns, swap anything for something better; consequently they are a body of wonderful unanimity in any cause that promises common good to themselves, and justice and fairness to others. They say to electric lights, "Burn, after our inspector has approved the manner in which you are installed and maintained"; and as a consequence there are in New England to-day, not including Boston and New Hampshire, 13,344 arc and 157,845 incandescent lamps radiating their beautiful bright light where the feeble flicker of the gas-jet and kerosene lamp could not penetrate.

So concerted is the action of these men, that were they, by reason of any necessity, compelled to say that electric lights shall not burn, comparative darkness would once more reign supreme in that fair land; but while they can continue to count upon their fingers the yearly fires caused by this modern illuminant, I think I can safely assure you that their dreaded power of extinguishment will not be exercised.

I have made exceptions of the city of Boston and the State of New Hampshire, the reasons for which are these:—The former, in its fire insurance matters, is supervised by a similar organisation to ours, known as the Boston Underwriters' Union, which handles electric lights in the same manner as our exchange. The latter, through antagonistic and unfair legislation, over two years ago caused the absolute retirement from that State of every outside stock fire insurance company, and they now manage that business by themselves. By what light they work we know not; but, judging from their sad experience of the past year, we are led to believe that they work by the unholy light of their own wicked ways.

I have described the character of our exchange principally to show the difference between it and most of the insurance organizations of our country, which are generally composed of officers of companies, or local and general agents in the large cities, between whom, by reason of their greater competitive relations, there exists a less cordial and familiar fellowship; and they are consequently less able to harmoniously and successfully devise and carry out methods of improvement and mutual good.

In the first year of our existence, some five years ago, we realised, after having paid considerable sums for losses caused by electric lights, that our interests demanded the inspection of all such apparatus by some person selected by ourselves, if we were to continue granting permits for the lights without charge. We were a year or two, in a sort of experimental way, in getting settled down to a perfect system of inspection; but the result of the two years immediately preceding 1887 showed us, for the labour we had undertaken, a loss of less than 8,000dols. from electric lighting in our territory. We had by that time not only given up all thought of making an extra charge for a permit to use your lights, as we do in many cases for kerosene oil, and in some instances for gas, but we were fast beginning to show our preference for your illumination by granting reductions in our rates of premium. The year 1887 has shown us a loss record from your lights something less than any previous year, notwithstanding the great increase in your installations; and the spirit of recognition of your superiority in point of safety has steadily gained ground, until I am happy to predict that before another month has passed the New England Insurance Exchange will have announced its favour in the form of a schedule of reduced rates, which it purposes to make on certain classes of risks where the exclusive use of electric lights is guaranteed. I think in this respect we will have fairly taken the lead.

A proposition to this end was made by the electric light committee of our exchange a year ago; but while we had for two years previous made an occasional reduction in rates, and have done so more generally during the past year, the time has not seemed ripe until now for an open announcement to that effect.

This feeling of preference for electric lights has been very gradual in gaining ground with us, and has reached a general recognition from the fact that the fires from that source have been few in number, and the losses small in amount; and this favourable result has most assuredly been due to our perfect system of inspection. In this claim I am supported by the greatly increased number of fires that are reported as occurring in sections where insurance inspection does not prevail.

That there are in your method of lighting many inherent possibilities of causing combustion and loss of property thereby, I need not claim, because none of you would for a moment deny it; but what I do want to claim, and mean to persist in maintaining, is, that there is no reasonable excuse for any fire to be caused by your apparatus, except in very rare cases, where some unexpected and unavoidable accident may occur.

It is quite possible for you to reduce the fire hazard of your system to the very lowest degree.

It is quite as *impossible* to do so with any other means of artificial lighting. How can any care or control be exercised over the promiscuous use of kerosene lamps while men, women, and children, including the careless, the thoughtless, the stupid, the old and feeble, the young and weak, are handling them? What can prevent the innocent but agile cat from upsetting the lamp carelessly left in its path, as it is not unfrequently accused of doing. Surely no insurance inspector, even with his ubiquitous habits, could prevent such catastrophes.

While greater care and a system of inspection could prevent some of the many explosions in the gas system, they could not prevent combustible material from coming in contact with the open flame, neither in the dwelling, the store, nor the workshop; nor could they prevent an occasional escape of gas through a leak, or a burner carelessly left open; and in that event no amount of cautionary rules could deter the innocent occupants of the premises from going in search of the leak with an open light in their hands.

While our policies distinctly exclude damage caused by explosion unless fire ensues, and then only cover the damage caused by fire, there is usually fire enough ensuing to "ring us in"; and the drawing of the line between the explosion and the fire is usually disastrous to us.

Therefore I hold that, while no possible human foresight can prevent fires from the old methods of lighting, it is not only possible, but quite an easy matter to prevent them in your case if you set about it rightly.

If I were to presume to offer advice in the matter, it would be this: Where insurance inspection is already being practised, combine among yourselves and support it by paying whatever is reasonable for carrying on the work in an intelligent and economical manner; also by helping them improve their rules and requirements from time to time, as your experience develops new means of safety.

Where such work is not being performed, get together in the same manner, those of you who are operating in that field, and ask the insurance men to appoint an inspector; then submit your work to him, conform cheerfully to his reasonable requirements, and go to the public with his approval. The approval by insurance companies of any lighting, heating, or power device is necessary. The public wants light, heat, and power; but it must have insurance, for on that the great commercial fabric of to-day depends for solidity.

By such inspection you will bring the fire hazard down to a minimum; you will largely increase the growing confidence of the public in your lights; you will rapidly clear away any lingering prejudice with insurance men against you; and, in place of opposition that you may now occasionally meet with from them, you will readily obtain their fullest indorsement—more than that, even, you will doubtless receive positive encouragement from them in the way of concessions in rates in many cases.

The two interests should harmonise and work together to the greatest degree. You have in your system of artificial lighting great possibilities of reducing the enormous fire waste considerably; while we have, through our endorsement and encouragement, the power to largely increase your development; and the two together can give mankind more light and better light, and they need it.

I do not hold that you are deficient in any degree as to what does and what does not ensure safety in your work, but I think you will agree that in the construction and

maintenance of your equipments you are sometimes obliged to depend upon those who are not so proficient in their calling as they might be. The good insurance inspector, who gleans his knowledge and experience from all, helps you to educate and improve in usefulness these employés to whom you trust your work. I refer particularly to the construction and dynamo men and the trimmer, and to the latter more particularly. If this functionary had possessed a knowledge of the possibilities of fire from the arc lamp, the losses from electric lighting in New England last year would have been too inconsiderable to mention.

Right here I wish to speak of a habit that sometimes possesses local companies—that of hiring inexperienced help because it is cheap. It is false economy, I think.

Competition, which is very great among you, drives you in some cases to lowering the standard of your material and work. It compels you to figure in every possible way to get the job. Nine out of you may be honestly inclined to maintain the highest degree of perfection, but the tenth one outbids you all by figuring for cheap work. Careful and conscientious insurance inspection brings him up to the rack, or shuts him out; and we all profit thereby.

The question of insulation was referred to in a pointed and timely manner by our friend Haskins a year ago, and his suggestions seem to have taken root in the East. Insulated wire is the rule, rather than the exception, in those places where insulation is most needed, and painted wire has "lost its grip." The difference in cost is too slight, and in point of efficiency and economy too great, to allow the reform to languish.

The location of central stations seems to be receiving merited attention, but not to that extent which the good of the profession demands. In the past the practice has been to secure power, especially in the smaller places, where it could be had the cheapest, without regard to permanency and surroundings. The result has been that you have gone into cramped quarters, with hazardous occupations on all sides above and below you. You have got power by using boilers already being worked well up to the limit of safety, or you have set other boilers in the limited space at your disposal. There have been fires and losses charged to you which you might have escaped by locating more wisely; and, as a consequence, too many insurance men now look upon the electric light station as one of the specially hazardous risks.

Locate by yourselves as much as possible. Build after modern fashions. Do not spare brick walls and cement floors where they will add to your safety, and then you will get lower rates from stock fire insurance companies, or our "Mutual" friend Woodbury will provide for you.

There are in New England, as many of you are aware, a dozen or more good, strong mutual fire insurance companies known as the "Manufacturers' Mutuals." They confine their acceptances of risks to the largest and best manufacturing properties in New England and the Middle States, and to a limited extent in the Southern States and Dominion of Canada. Mr. C. J. H. Woodbury is one of the vice-presidents of the largest of these mutual companies, and the recognised expert authority for them all. About five hundred of the large manufactories insured by them are lighted by electricity, either arc or incandescent, and very largely isolated plants. They have received the inspection of Mr. Woodbury, and the greater part of those in New England that of Inspector Brophy also. I take pleasure in quoting from a letter on the subject just received by me from Mr. Woodbury. He says:—

"When electric lighting was first introduced it was the cause of a great many fires, there being twenty-three fires from this source in the sixty-one mills using it in 1881 and 1882. By April, 1882, all the electric lighting plants in property which was insured by the Mutuals had been changed to conform to the rules for installation which I had prepared in December of the previous year, and since that time we have not had a single fire from electric illumination. I do not know of any fires caused by electric lights which did not owe their origin to a disregard of principles laid down in those rules as essentially for safety."

I think that statement bears me out in my assumption as to the almost entire immunity from fires due to artificial lighting that is attainable by the use of your methods, and I ask no better support.

Mr. Ridlon has advanced some excellent ideas looking to better work in point of safety in construction and maintenance—that of examination for fitness and qualification of the men who do this work, and the granting of certificates to them if found competent, the same as is done in the case of steam engineers. He would have the board of examiners composed of electrical and insurance experts. My only criticism is that his ideas fall short of the whole necessities. The absolutely impartial inspector is still needed to see that the "tenth man" of whom I have previously spoken does not prosecute his nefarious work without a certificate; also to see that those who hold certificates are not entrusting their work to cheap men who don't hold them, or that the guileless trimmer is not falling into the habit of leaving the bottom off his arc lamps.

I would not occupy your time with technical suggestions—if, indeed, I had any to offer—because they had better be left to printed rules and inspectors; but it may interest you to know to what extent your business has prospered in New England. The following figures are taken from our inspection records, and are probably about right; they are inclusive of Boston, but exclusive of New Hampshire. For comparative purposes, I give them as they stood at the beginning of 1886 and also 1888.

Number of Arc Light Central Stations.

	1886.	1888.
In Massachusetts	26	45
Rhode Island	5	8
Connecticut	9	21
Maine	4	14
Vermont	none	5
Totals	44	93

Increase, 1888 over 1886, 111 per cent.

Capacity of above in Arc Lamps.

	1886.	1888.
In Massachusetts (including 2,168 in Boston in 1886, and 2,475 in 1888)	3,693	7,305
Rhode Island	831	1,961
Connecticut	782	3,311
Maine	520	1,465
Vermont	none	415
Totals	5,826	14,457

Increase, 1888 over 1886, 148 per cent.

Number of Incandescent Lamps from Central Stations.

	1886.	1888.
In Massachusetts (including 9,000 in Boston in 1888)	8,600	74,500
Rhode Island	600	2,200
Connecticut	none	11,050
Maine	400	8,100
Vermont	none	1,400
Totals	9,600	97,250

Increase, 1888 over 1886, 913 per cent.

Number of Arc Lamps in Isolated Plants.

	1886.	1888.
In Massachusetts	459	721
Rhode Island	416	731
Connecticut	223	332
Maine	10	50
Vermont	58	128
Totals	1,166	1,962

Increase, 1888 over 1886, 68 per cent.

Number of Incandescent Lamps in Isolated Plants.

	1886.	1888.
In Massachusetts	16,003	40,619
Rhode Island	4,140	9,546
Connecticut	2,117	11,050
Maine	1,860	6,908
Vermont	none	475
Totals	24,120	68,598

Increase, 1888 over 1886, 184 per cent.

Total arc lamps, 1886, 6,992; 1888, 16,419. Increase, 1888 over 1886, 135 per cent. Total incandescent lamps, 1886, 33,720; 1888, 165,848. Increase, 1888 over 1886, 392 per cent. Total arc and incandescent, 1886, 40,712; 1888, 182,267. Increase, 1888 over 1886, 348 per cent.

Those of you who may know the ratio of increase in other sections of the country for the corresponding period, can judge if New England insurance supervision is a detriment to your business or otherwise.

A whole year without any considerable fire loss in our country from electric lighting would be a splendid record, but none too good for any of us to contemplate. While such a result is far outside the bounds of probability in the present condition of things, it is well inside the bounds of possibility. As well might we hope to revolve the earth from east to west as to hope for anything short of millions of dollars of fire loss annually from the old methods of illuminating by combustion—the candle, the gas, and the kerosene oil flame, and the accompanying friction match.

THE BRITANNIA COMPANY'S LATHES.

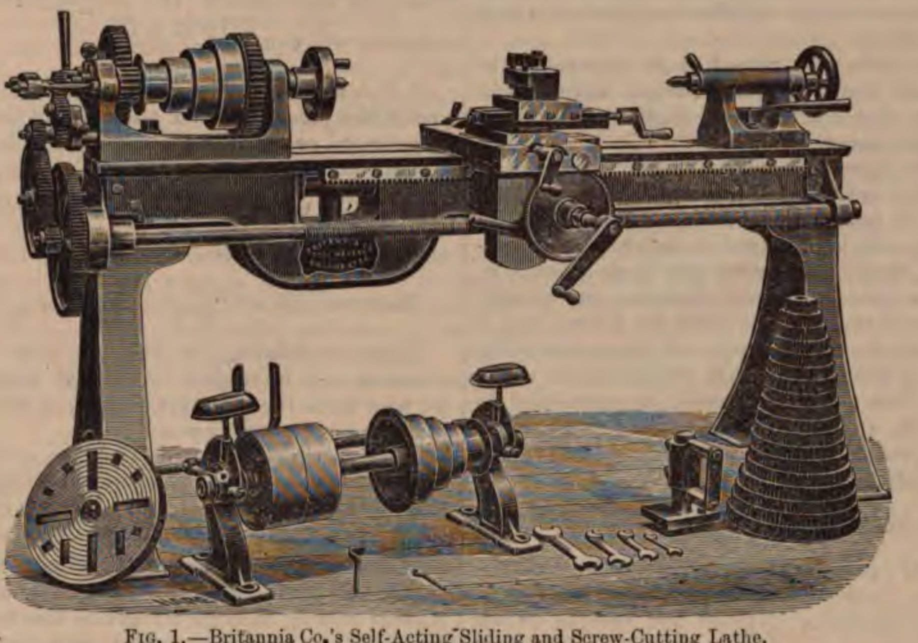


Fig. 1.—Britannia Co.'s Self-Acting Sliding and Screw-Cutting Lathe.

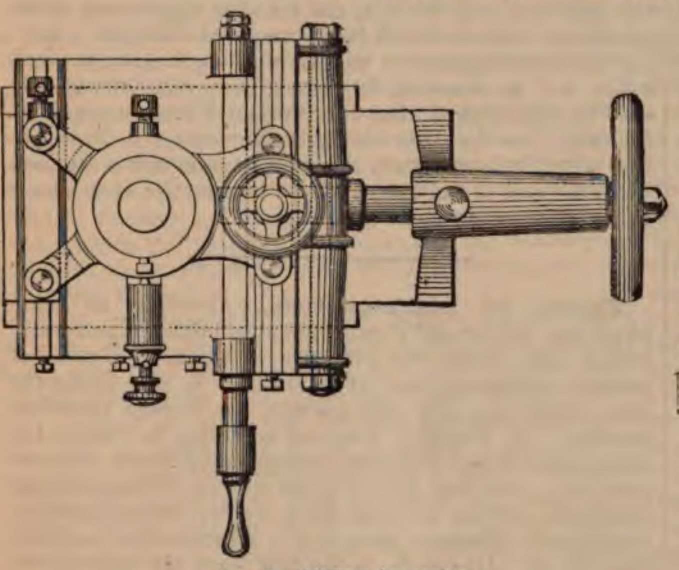


Fig. 2.—Milling Apparatus.

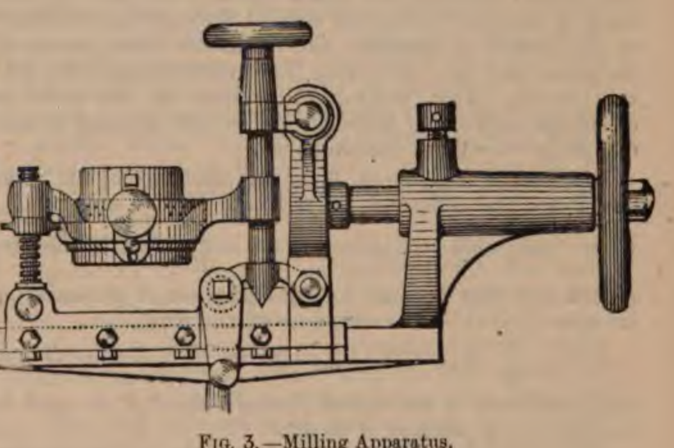


Fig. 3.—Milling Apparatus.

Colchester is the home of two or three firms whose names are becoming household words among electrical engineers. Messrs. Davey, Paxman, and Co. of course take the first place. Prof. Forbes and others, in the discussion on Mr. Crompton's paper, pointed out that some of the American makers reduced the number of types of machines they constructed, and made the parts interchangeable. This means a good deal of lathe work; and we now call attention to the Britannia Company, of Colchester, which company is making a speciality of lathes. We herewith illustrate (Fig. 1) a very useful form of lathe, made of the best materials, and fitted with all the improvements practice has found necessary. An illustration of this kind practically explains itself. The company is also introducing the Greatorex patent milling machine, illustrated in Figs. 2 and 3. This apparatus is fixed on the lathe bed at a convenient distance from the headstock, the cutter being already in its place, and a suitable chuck used. Full instructions are given with the apparatus. The cutter can be replaced by a drill when drilling is required.

FORMULAS FOR WIRING.

BY ELMER E. E. EMMONS.

Mr. Crockett's diagram for incandescent wiring [reproduced last week from the *Electrical World*], although good in its way, and saving a large amount of work in calculating, is only a partial solution of the problem. The diagram, as it was remarked in an editorial of the same issue, is only

useful under certain conditions—viz., in systems of two or three wires, having the potential and current given with the diagram; for all others it is useless.

Every central station should have diagrams for each system it uses, each diagram to be used only on that system for which it is constructed.

If such a diagram is properly made, and the men instructed in its use, it will be the means of saving considerable time and securing accuracy.

But in the general application of electricity, the factors, current, and potential, are variable to such an extent that it would be impossible to have a diagram to meet all wants. To men having to do wiring, such a variety of conditions are sure to present themselves; and what is really needed is a formula that will fit any case, be it lamps or motors to be supplied, it being immaterial whether the current is taken from dynamo or battery.

I find that most men who have had no experience in mathematics beyond the common arithmetic have a holy horror of anything that resembles an algebraical formula, and, however simple, pass it quickly by.

Now, an algebraic formula is only a rule concisely stated —an idea which they entirely fail to grasp. The same men would read a rule in arithmetic and do an example by it; but when that same rule is presented in the shape of a combination of letters, they immediately turn their backs to it. Any man having a common school education can readily work out any formula that may be given for wiring, and, if he knows the reasons for its structure, will the more readily comprehend and use the same. Such a formula can easily be deduced from Ohm's law, may easily be committed to memory, and will be found invaluable, not only in determining the size of the wire, but in finding the percentage of loss in that already in place.

Ohm's law reads thus: $C = \frac{E}{R}$; that is, the current flowing in any circuit is equal to the electromotive force of the battery or dynamo divided by the resistance of the whole circuit, *i.e.*, of the battery or dynamo and outside circuit combined.

Now, the E.M.F. is the whole force tending to drive the current through the entire circuit; but part of that force is used in driving the current through the resistance of the battery or dynamo; the remainder being found at the poles, and used in forcing the current through the outside circuit. That balance of pressure at the poles is called the *difference of potential, and is just sufficient to send the current through the external circuit.*

Let C stand for current, R for the resistance of the wire, and P for the difference of potential at the ends of the wire. Ohm's law will then read: $C = \frac{P}{R}$; that is, the current in any wire is equal to the difference of potential at its ends divided by the resistance of the wire.

If $C = \frac{P}{R}$, then $CR = P$; that is, *the resistance of any wire, multiplied by the current flowing through it, is equal to the difference of potential at its ends.*

The resistance of 1ft. of pure copper wire, one-thousandth of an inch in diameter, is equal to 9·94 ohms, and if the wire used has 95 per cent. of the conductivity of pure copper, its resistance will be equal to 10·46 ohms.

Let L equal the length of the wire to the lamps, or motor, and back. Then if 1ft. of wire one mil. in diameter equal 10·46 ohms, a length of L feet will be equal to 10·46 L ohms. But the resistance of a wire varies as the cross-section, that is, the greater the section the less the resistance, or, more accurately, it varies inversely as the cross-section. To use the cross-section in our formula would add to the work in calculating, because it is the diameter we are after.

We may now inquire into the relation between the cross-section and diameter.

Take the case of three wires, *a*, *b*, and *c* having the respective diameters d, d_1, d_2. The cross-section of *a* will equal $\frac{\pi}{4} d^2$; that of *b* equals $\frac{\pi}{4} d_1^2$, and of *c* equals $\frac{\pi}{4} d_2^2$. π is the ratio of the circumference of a circle to its diameter.

From the above we see that $\frac{\pi}{4}$ is a constant, for the expression appears in each case; the only thing that varies is d^2.

We therefore conclude that the section varies directly as the square of the diameter, which will make the resistance vary *inversely* as the square of the diameter.

We may now write for the resistance of our wire of length L in feet: $R = \frac{10·46\,L}{D^2}$; D being the diameter of a wire expressed in thousandths of an inch or mils.; and D^2 being consequently expressed in circular mils.

Now as the potential, P, required to force the current, C, through a given resistance, R, is equal to the product of the resistance and current, the potential lost in the wire of length L will equal $\frac{10·46\,L\,C}{D^2}$.

If P is the potential required to run the lamps or motor, and N the percentage of P to be lost in the wire, the amount of potential or electric pressure lost will equal P N. As P N is the potential to be lost in the wire, these two quantities must be equal to each other; that is, $P\,N = \frac{10·46\,L\,C}{D^2}$, and $P\,N\,D^2 = 10·46\,L\,C$.

Therefore, $D^2 = \frac{10·46\,L\,C}{P\,N}$ and $D = \sqrt{\frac{10·46\,L\,C}{P\,N}}$.

Tables containing the different sizes of wire and their diameters can be readily obtained of manufacturers, and as we now know the diameter, we can, by referring to the table, find the corresponding size.

Anyone acquainted with the laws governing the flow of current may readily develop such a formula, and to show how short and clear the above formula is, we may write it as a rule in arithmetic would be written, as follows:—

Multiply the resistance of 1ft. of wire ·001in. in diameter of the given material by its length in feet and by the current flowing through it; divide this number by the product of the potential required by the lamps or motor, and the percentage to be lost, and take the square root of the quotient; the result will be the required diameter. Anyone on comparing the two will see that the formula is much easier and its meaning less liable to be misconstrued. It may be remembered that Sir William Thomson gives the following law for determining the percentage to be lost in the wire: In any system the greatest economy is attained when the cost of the energy lost in heating the wires equals the interest on the cost of the copper.

Theory of Diamagnetism.—According to many physicists, Weber and Tyndall amongst others, diamagnetic bodies take, under the influence of magnets, a state of polarity opposite to that which is taken by iron under the same conditions, and this opinion has become classic in teaching. M. Blondlot, however, according to *Cosmos*, has demonstrated that in reality diamagnetic polarity does not exist at all; and that, following the opinion of Becquerel, all substances and the air itself are, in reality, paramagnetic, a diamagnetic substance being only a substance less magnetic than the air. He recalls, in the first place, the experiments which led Tyndall to his conclusions. A bar of bismuth, placed on a coil and submitted to the action of a powerful electro-magnet, takes contrary poles to those which a bar of iron takes under the same conditions. The experiments of M. Blondlot show that bismuth becomes magnetic in the same manner as iron, but that the change in its polarity arises from the fact that the medium which surrounded it is more magnetic than itself, when the medium is air. He replaced the bar of bismuth by a tube filled with a weak solution of perchloride of iron in methylated spirits. This tube is magnetic, and becomes magnetic in the same manner as the bar of iron when it is in air, a medium less magnetic than itself. But when it is plunge in a vessel containing a *concentrated* solution of perchloride of iron, a medium more magnetic than itself, it becomes magnetic like the bar of bismuth of Tyndall's experiment.

MOTORS FOR NAVAL AND MILITARY USE.*

BY LIEUT. B. A. FISKE.

The reply of Clerk Maxwell, when near his death, to the question, "What has been the greatest discovery of the age?" "That the Gramme machine is reversible," shows, in the light of recent years, an inspiration almost prophetic. Granting all the benefit to mankind resulting from the numerous other discoveries with which the century has been laden, surely none surpass in far-reaching consequences the very simple one that, if a current of electricity be sent through a dynamo from an external source, the dynamo will at once become a motor—*i.e.*, an engine, and the most efficient engine known.

But so rapid has been the development of the electric motor, that many persons, whose attention has been devoted to other things, have failed to grasp its full significance; and the object of the present paper is to present a brief statement, showing, not that the electric motor is a piece of apparatus of possible usefulness in the future, but that it is to-day a complete, durable, and strong engine, better adapted for handling guns in ships and forts than steam, hydraulic, or pneumatic engines, and more desirable for use in ships for certain auxiliaries than the numerous little steam-engines with which they are filled.

On the principle that it is best to begin at the beginning, Faraday's pregnant discovery may be recalled, that the movement of a coil of wire near a magnet pole produces a current of electricity in the wire, and the action of the dynamo at once stands out clear, because a dynamo is nothing more than an apparatus for revolving a coil of wire near a magnet pole, or, more strictly, for revolving several coils of wire between two magnet poles. Between these poles is the "armature," consisting of a number of coils of wire so mounted on an axis as to be capable of revolution. If this armature be revolved by any means whatever, such as a steam engine, a current of electricity will be produced in the coils, which will pass to the outside wires by means of the stationary brass strips or "brushes." For convenience, this wire is usually wrapped around the magnets, in order to avoid using an external source of electricity to produce the magnetism. Now, though the shape of the magnets and the armature may be varied in a thousand ways, this is all there is in a dynamo that is essential.

If the armature is not revolved, no electricity is of course produced; but if we send a current of electricity from an external source through the dynamo, it at once revolves in the opposite direction, exactly as would a rotary pump if we sent a stream of water through it; and the amount of work which the dynamo or motor will be capable of doing will depend entirely on its size and the amount of current sent through it.

Perceive the simplicity of this engine—a heavy and strong electro-magnet, a pair of brass brushes, and one revolving part, the armature composed of wrought iron wrapped with copper wire and strengthened with metallic bands. This is all: no valves, no stuffing boxes, no glands, no packing, no crank pins, no reciprocation of parts, with consequent and inevitable lost motion, no water in cylinders, no perceptible radiation of heat, no smell, no thump, and almost no liability to get out of order. Anyone desiring to see for himself the uniform and unattended performance of an electric motor can easily get permission to visit the operating room of the Gold and Stock Telegraph Co., in New York, and watch the electric motor running the transmitter which furnishes stock quotations to the city. It requires very little familiarity with the printing telegraph to perceive that the transmitter which controls quotations involving millions of dollars must run with absolute regularity under all conditions; and the visitor will find in one corner of the room, out of the way, and almost out of sight, a motor of about 3 h.p. running so silently as to be almost inaudible. And there it has run for three years, patiently performing its allotted task, simply asking that its two or three oil cups are occasionally filled, and its two brass brushes occasionally replaced. Yet the armature is balanced so nicely, that it would require very long-continued neglect of oiling to do much harm; and the only injury that would occur if the brushes were neglected for, say a day, would be one easily remedied, and unattended with the slightest danger.

On board the "Atalanta" we have a steam capstan on the forward berth deck, supplied with steam by a 4in. pipe and connected to the auxiliary condenser by a 4½in. pipe. By reason of the distance between this engine and the boilers, with the consequent friction in the pipes and condensation, the steam pressure is much reduced, and the back pressure much increased, so that a larger engine is necessary than would otherwise be the case, and, which is not astonishing, it has been known to run very much faster in weighing anchor, when exhausting into the atmosphere and covering the forecastle with a cloud of steam, than when exhausting into the condenser. Now, an electric motor for running the capstan would not only have the advantages already mentioned, but could be connected with the same main wires as those furnishing the electric lights by two wires, say ¼in. diameter, thus avoiding altogether the expensive copper pipes, tinned on both sides and lagged.

The same remarks apply to the blowing engines, and one has simply to watch for a few minutes the comparative performance of even the best steam blowing engine and an electric motor, with the fan on the same shaft, to become convinced of the superiority of the latter.

For pumps, except the pumps very near the boilers, where the length of piping is short, electric motors would have the advantages mentioned above, and no disadvantages whatever.

For steering engines the simplicity of the apparatus, the quickness with which the motor could be handled, its freedom from liability to derangement, its absence of heat, and its noiselessness would commend it to anyone who has ever been shipmate with a steam-steering engine like the one on board the "Atalanta," which, though efficient and reliable, is as complicated as a printing telegraph, keeps the after end of the ship almost at a cherry-red heat, and threatens to shake the teeth out of the officers and crew every time the helm is put hard over.

Three years ago the ability of electric motors to train guns was shown to the authorities in England, and since that time much progress has been made in perfecting the apparatus for applying electric motors to this kind of work. Little difficulty has been experienced, for, though there is nothing that requires such accurate and rapid handling as a great gun in a seaway, there is no other engine capable of such accurate and rapid work as an electric motor, and its advantages over steam, hydraulic, and pneumatic engines are so marked that it would be idle to compare them. The indications now are that we shall have at least one gun in the "Chicago" trained by electricity, though possibly this may not be done, since the dynamos for generating the necessary electricity have been placed above the water-line and exposed to the enemy's projectile, while the beef, pork, bread, &c., have been placed below the water-line and securely protected therefrom.

But it is not in the training of the guns alone that motors can be advantageously employed; they can also be used in elevating. In the "Atalanta," when rolling from 10deg. to 20deg. each side, and from ten to twelve times per minute, the line of sight of the guns sweeps past the horizon so fast, even near the end of a roll, as to require from the gun captain a rare degree of skill if we would have him shoot as accurately as such fine guns should be shot. The trouble is that the gun is beyond his control except in the matter of training, because the most that he can do is to wait for a favourable time of roll and catch the line of sight on the target as best he can. To use the gun effectively he needs some arrangement by which he can put the gun on the target and keep it there, independently of the rolling of the ship. He needs some arrangement like the shoulder-piece of the Hotchkiss guns, by means of which experiments on this ship have shown a very little practice enables a man to keep the line of sights almost exactly on the horizon or on any other object.

Electricity puts this power directly into the hand of the gun captain; for by means of a small electric motor on the elevating gear and a suitable switch, he can raise, or lower, or stop the gun by simply moving his hand. The gun captain being able to train the gun to the right or the left, and to raise it up or down, the only thing left to do is

* From the *Army and Navy Journal* (U.S.).

to give him an electric primer, fired by means of an ordinary "push button," so that he can fire the gun quickly when the sights come on, instead of losing time by hauling on a lock lanyard.

The advantage of this quick means of firing by using the electric primer stands out clear when we recollect that in a ship, say the "Atlanta," which rolls in a seaway about 3deg. per second on the average, an error on the part of the gun captain of only $\frac{1}{10}$th of a second of time means a vertical error, on a target a sea mile distant, of about 31ft. This remark applies, of course, only to the individual firing, and not to broadside firing by electricity, the advantages of which are not so palpable.

A very neat use for electric motors would be for hoisting ammunition. On board the "Atalanta" we use five men at each shell hatch, and their work could be done more quickly and quietly by a 2h.p. motor costing, say, 200 dols. This would require one man to operate it, and would leave four men from each hatch for work at the guns. Coal could be similarly hoisted on board, and how refreshing it would be in coaling a ship to see two 5-h.p. motors running up the coal bags, instead of a long line of dirty men, hopelessly dragging on the yard and stay from morning till night, while the officer of the deck, a respectable man of forty, and the father of a family, incessantly and mechanically bawls at them to "haul away!"

But it may be objected that electric motors entail loss of energy, since steam-engines use steam direct from the boilers, whereas motors require dynamos to generate the necessary current, the dynamos themselves being turned by steam-engines, so that there are two losses—one loss in connecting the mechanical energy of the steam-engine into electrical energy; the other loss in reconnecting the electrical energy of the current into the mechanical energy of the motor. To this it may be answered that 15 per cent. loss for each transformation is a very fair allowance, so that the motor would deliver about 72 per cent. of the energy of the dynamo's engine; and it may be doubted if the auxiliaries which are at any considerable distance from the boilers work with more than 72 per cent. of the difference in pressure between the boilers and the condenser, by reason of the loss in friction and condensation in the steam and exhaust pipes. In fact, in engines which run intermittently, like capstan, steering, and gun-training engines, it may be doubted if any such efficiency as this is even approximated. This is a fair comparison, because the dynamo engine can be very near the boilers.

Since all our new ships are fitted with dynamos for feeding electric lights, why not have them feed electric motors also, every horse power developed by the motors being about the same thing as adding, say, nine 16 c.p. lights. Of course, the dynamos must be safe below the water line, and they must all be similar, and feed into the same main wires, which go all through the ship like gas pipes through a city, the incandescent lights, search lights, and motors receiving their supply from these main wires, and one, two, or three dynamos being run at a time, according to the number of lights and motors in use. Nothing could be more simple and effective than such an arrangement, and nothing could contribute more to the efficiency, health, and comfort of a ship.

To summarise, the advantages of electric motors, in ships and forts over steam, pneumatic and hydraulic engines are:—

1. They are more simple.
2. They are more durable.
3. They are more quiet.
4. They are more clean.
5. They have no swell.
6. They require less attention.
7. They avoid the troublesome and very expensive operation of leading steam and water pipes through a ship, especially through water-tight bulkheads.
8. The wires take up less space than pipes, a great point in crowded engine rooms and firerooms.
9. A water or steam pipe presents a much larger target than a wire, and is therefore more liable to be struck in action.
10. If a steam pipe or a water pipe is struck in action, the deck is filled with scalding steam, or is flooded with water under high pressure. All the engines depending on it are put *hors de combat*, and it is quite impossible to repair it; whereas, if an electric wire is so struck it can be repaired in a minute by simply bridging the gap with a wire.
11. The electric motor places in our grasp the best known means for handling guns, by reason of the readiness with which it is controlled.

In any ship arranged with a central of electric power and with main wires leading therefrom all over the ship, so that any desired amount of power could be obtained by simply moving a button as in lighting an incandescent lamp, a number of small portable motors could be placed wherever desired about the decks, and employed for such purposes as hoisting ammunition, coal and ashes, working the yard and stay, running lathes in the ordnance and engineer workshops, running small ventilators, &c.

The writer is aware that, in representing the benefits to arise from the use of electric motors on shipboard, he will fall under the disapproval of many of the best officers, who deem it unsailorlike to do ship work with machinery. But he feels assured that the navy is daily losing much by not seizing the advantages offered by electric motors, and that there are many officers who believe that the navy should not only preserve the glorious traditions of the past, but should also grasp the possibilities of the present. Let these note that, as said above, electric motors are no longer scientific or "theoretical" curiosities, but practical and strong machines, waiting simply to be used in order to contribute to the effectiveness, health, and comfort of our ships and forts, and that they can be bought in open market, or by advertisement, like beef and pork, and can be stowed on either the port or the starboard side. It is as certain as anything can be that naval and military people will some day use them. The only question is, will we be as slow in taking advantage of them as we were in taking advantage of steam-capstans, steam-steering engines, steel ships, and square air ports?

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—May 18.

CENTRAL STATION LIGHTING: TRANSFORMERS v. ACCUMULATORS.—MR. CROMPTON'S REPLY.

Mr. R. E. Crompton, in reply to the discussion on his paper on "Central Station Lighting: Transformers *v.* Accumulators," said that in his replies to his critics he would put the answers into two or three groups, which would answer others who had spoken on the same points. First, in reply to Mr. Hammond. Mr. Hammond seemed to labour under the idea that he had stigmatised his installation as an "advertising" station. What he did say was that Mr. Hammond's and other similar installations were pioneer stations, established more for the idea of showing to the public what electricity could do than as being model installations of central lighting, and this, he maintained, was the case with all overhead wire systems. It would save much misunderstanding at this point, and a further misunderstanding when he came to answer Prof. Forbes, if he stated that for the purposes of this paper his object was to discuss transformers *v.* accumulators on their merits for certain installations as central stations for the City of London, and for this purpose overhead wires were put out of call. He wished to limit the discussion to a practical issue for such a system. Mr. Kapp criticised the load diagram shown, saying that the valley in the diagram might be filled up with power used in the day, and a larger total supplied for the same plant. He did not deny this in many cases, but London was not like New York and other cities. The offices are grouped together at the City, and, of course, the diagram for the City would be widely different; but the matter of supreme importance at this time is the lighting of the houses in which we live, for that is where we feel the full benefit, and everything we can do to forward such lighting is the most desirable at the present time. As to the sale of motive power, no doubt that was most desirable, and told in favour of the battery system, although he did not give very great weight to that point at present; in future it would help to swell the income. The capital required is proportional to the height of the *peak* of the load diagram, and the income is proportional to its *area*; therefore, the more it is filled up the better for the company. In discussing the question he had kept this point out of view, and his motives would be appreciated for keeping it thus one-sided for the purpose of comparison for lighting only. Every argument he had used would be strengthened if motive power were distributed. Turning now to the discussion in his absence, Mr. Kapp seemed to misunderstand the figures as to the cost of laying cables; he says, instead of using the cable proposed, costing £116 per 100 yards, he proposes using a cable covered with lead at £130, and he hopes by this expedient to save a great deal of expenditure. In this he will find himself quite wrong. He seems to think 3s. per yard will be sufficient for laying such a cable. Did he know that £25 per 100

yards is the lowest sum levied by the vestry when the roads are taken up? For ordinary pavement, 4s. a yard is the price, and for asphalte, 11s.; but if we suppose 10 per cent. only of asphalte, this will make the cost 5s. a yard, making £25 per 100 yards. Moreover, in calculating his cost of laying, Mr. Kapp makes this astonishing mistake: he thinks he can find contractors who will carry out his work at cost price, without taking a profit. How he can think he can find contractors who will consent to take up pavements and guard against contingencies, without making their profit, is hard to say. Mr. Kapp having left out the amount to cover drawings, management, and profit, you will find his figures come considerably higher than mine. This is a specimen of Mr. Kapp's figures, and you will find his other objections on the score of cost will no better bear inspection. The laying of the mains will be the chief item in any coming installation. We have had no experience of the cost of laying mains until the last few years, and he really had thought it would prove of weight if he gave figures as to cost of cable actually laid. General Webber in his criticism of the culvert system misunderstood the way in which the wires are fixed. General Webber talked of suspending the wires from the roof of culvert; if that was the case no doubt water would trickle down and reduce the insulation, but, as a matter of fact, the cables were strung on short pillars standing up in the culvert, and there was no reason to fear even if there were two or three inches of water running on the trench. It seemed to be imagined that these culverts would be stopped up with mud, and legions of rats would be running along. They had had over one year's experience with the culvert system, and had had no such things occur, nor any signs of such occurring. They have had the trenches open many times, more than they would in the future, and many joints made, and, in spite of all, the insulation is actually at the present moment, length for length, as high as that of the highest insulated cable yet made in the world. While on this point, he wished to make a remark upon the question of underground insulated cables. It is quite common to stipulate the resistance of a cable to be so many meg-ohms. As long as the insulating covering remains intact, it is very easy to keep the resistance such that it can be measured by meg-ohms; but when it has a few hundred cuts in the covering and joints are made, the resistance cannot be prevented from falling. No matter how carefully the joints are insulated afterwards, some leakage will take place at every joint, and the resistance comes down to a few thousand ohms. In speaking from practical experience, he found the joints very difficult to make electrically tight; and whoever came to plan a system with high-tension mains would find the difficulty infinitely more than with his system. As to the difficulty of placing culverts, it was true that there are some places where the culvert system could not be used. It has been thought that it was necessary to use an 18in. culvert; but in many places he had only used 5in. culverts. It was also thought that the cables would sag down and short-circuit. If properly run, there was no danger of this; but he should prefer a midriff, in brickwork, between each set of cables to prevent the possibility. The greatest difficulty was in getting sufficient depth free from cross-pipes. In some cases there was no more room than 2in. available, when this is the case no system can be used but lead-covered cable driven through small pipes. As to the relative cost of transformers, Mr. Kapp thought that the number of transformers could be reduced, and went to the extreme of putting transformers in ten different sub-stations. Mr. Kapp had already pointed out the saving of mains by using transformers, but by using ten distributing transformers he will use just as much copper as in distributing from ten battery stations. Mr. Kapp would, therefore, have to adjust his figures, and by this means he must add £6,000, and in addition sub-mains from the ends to the charging mains, about £3,000 or £4,000 more. That is an addition of £10,000 for a gain of £3,500 in cost of transformers. This is a specimen of Mr. Kapp's proposal to reduce the cost. From what had been learnt from Prof. Forbes, however, he did not think that Mr. Kapp's proposal would be carried out, but a transformer would be put in to every house, or at least, one for each two houses £15 for each two houses would not be too much to include profit and similar charges, and he did not see how this figure could be reduced. He might just touch on the question of efficiency at low rates of output. In the transformer system, 40 per cent. of the total output is taken at extremely low rates of efficiency, a transformer of 4,000 watts capacity giving 180 watts. During the corresponding time the efficiency of the accumulator is at its highest. Mr. Swinburne made the remark that transformers could be made to give as great an efficiency at low as high rates of output—that is, that they could be compounded. The truth was, the transformers "compound down," the E.M.F. falls as the current falls, and the manufacturers of transformers have not yet succeeded in winding them so as to obviate this. This brings us to another point, which, apparently, he had not sufficiently dwelt upon. The paper did not deal with accumulators simply as storers of energy, but dealt with accumulators *as transformers*; and, although many persons have discussed the objections to the storage battery, Mr. Drake was the only person who dealt with their advantages from this point of view. There are two distinct plans of using batteries in a distributing plant—the one, in which batteries are interposed in the charging circuit, and transform a high-tension current into a low-tension current, having at the same time a storage capacity in case of breakdown, and for sudden increase of output; the other plan is that in which the batteries are filled during the daytime and discharged at night. Mr. King had alluded to the installation of Colchester, and asked why he had not referred to it. The arrangement at Colchester was so different from that he was now advocating that it is out of count; the number of batteries would have to be multiplied by six, if used as they were used at Colchester. You would see that after all he was a very timid user of batteries; no doubt as experience extended he should use them much more largely, and we may be able to have the mains reduced, and have more distributing stations and larger generating plant, but the whole of the figures given were based on experience up to this present moment. He had done it before and could do it again; whereas, even what was supposed about the transformer system had not been done yet. He had been called to account for not publishing the figures of the Vienna installation. He did not choose to publish those figures for this reason, that he was contractor to the company, and put it to the audience, would they, being contractors, publish figures which might endanger their position as contractors to the company. But he would do this—he would agree to take, say, Sir Wm Thomson to Vienna, and prove to him that there was not the least difficulty, or hitch, or danger to life or limb, with the battery system there in use. Prof. Forbes speaks with deprecation of an insignificant installation of 10,000 lights, and says the proper basis is 100,000; but Prof. Forbes might notice that 20,000 yards of wire was allowed, and that 10,000 lights is one-tenth of 100,000, and might very reasonably expect to increase to that amount without much difficulty. Mr. Kapp objects to the rent of accumulator stations, saying that £150 extra must be allowed. The sum of £50 is the rent now actually paid for stable and coach-house, and there are at least a dozen others offered at this price, and, more than this, a single room cannot be had for much less than this. People do not care about letting part of their houses. As to the efficiency of the accumulators, Mr. Parker doubts whether 80 per cent. efficiency can be obtained with the accumulators. In reply, he could only state that this efficiency *is* obtained at Vienna, and higher efficiency has been obtained. It is easy to understand that this can be done when the batteries are used as transformers, and not as mere storage batteries to be charged in the day and discharged in the evening. In the first case it is the watt efficiency that must be taken, the watts at the dynamo divided by the watts at the terminals of battery; in the second, current efficiency only. Here watt efficiency was spoken of, and that loss of conversion is not always to be taken into account is due to the fact that when the batteries are connected in series and taken off in parallel, if there is no leakage there is no loss and leakage across the terminals can be guarded against, and need not occur. It is more likely to occur in a private installation, but in a large installation there is sufficient staff to prevent this loss, and it pays to prevent it. Forty per cent. of the total output is at a low rate of output, on which there is no loss; the remainder is at 80 per cent. efficiency, the total efficiency over wires and all is over 70 per cent. As to the depreciation of accumulators, all the experience we have goes to prove that we are well within the mark when we say we can guarantee a depreciation of not more than 12½ per cent. The company at Vienna are not willing to allow anyone to contract, even at 10 per cent., finding that they can do it themselves for less. The experience at Kensington Court has shown a depreciation during 15 month of about 2 per cent. There is a battery at Chelmsford, which is in exactly the same state as it was last year, and has not lost one penny in depreciation, and there was no reason why it should during the next year. It has not been lightly used either, having been in more or less constant use, giving large currents for calibrating instruments. Mr. Kapp objects to 4 per cent. variation, and suggests 2 per cent. We have found no trouble in this respect, and think, as long as it is not exceeded, 4 per cent. would not be grumbled at. Mr. Hammond says that, practically, engines do not fail suddenly, but always give some warning. All he could say is that in Mr. Hammond's experience must be very favourable; his own experience was that engines stop just when they ought not: a journal of a big engine gets heated—a few revolutions, and it slows down. How about the belt coming off? It must stop suddenly then, and have we never heard of such a thing as the belt breaking? At all events, this is what you can do with accumulators: you can stop right in the middle of the busiest time for two or three hours for repairs. In one case they had been able to stop the engine and get up steam in another boiler without the people knowing anything at all about it. Now as to Prof. Forbes' remarks. A large proportion of Prof. Forbes' remarks were mere carping criticism. He would take a few of his remarks, and the audience might judge for themselves. He says there are only two cases of actual experience in the paper, and both of them are "hearsay" evidence. If Prof. Forbes will look at the paper, he will see that in both cases of what he calls "hearsay" evidence was about accumulators made by other people. He could answer for his own experience, but in the case of the accumulators made by Elwell and Parker, or by the E.P.S. Company, he took what they said, and they should know. He really did not think that he was the one to be accused of speaking from "hearsay" evidence. He asked, Has there been any paper given before this society in which there has been so much real practical, commercial, contractor's experience, as the one now brought before it? Of theories and principles we have had sufficient, but of real practical experience very little. He felt sore on this point, as he had tried to give some really useful information and put himself to a good deal of trouble and expense over the matter, and was now told that it is of no practical use by Prof. Forbes, who does not know himself the cost of laying a main, who never paid a contractor, who never checked a contractor's account, and practically knows no more about—well, Prof. Forbes ought to be very good at figures, but he is not good at contracts. Prof. Forbes says the reserve is too much—1,450 h.p. he thinks is far too much; and gravely informs us that Mr. Westinghouse gets 600 kilo-watts from 1,000 h.p., —that is, 81 per cent. e.h.p., as if effective e.h p. in the cylinder were the same as effective e.h.p. at the terminals of the lamps. Never was there such argument. What is more, he fancies we are rather below par in making engines and dynamos. Let him tell Prof. Forbes that Willans and Robinson, down at Thames Ditton, make the best engine for dynamos. Westinghouse has simply copied the Willans engine—copied everything, and a very bad copy too—and is supposed to get 12 per cent. greater efficiency than the original, and this is in the highest part of the scale, when every increase of efficiency is so difficult to obtain. Is it actually likely, when Prof. Forbes accepts such statements as these, that his strictures on what we are able to manufacture are very good, and the rest of his strictures may be measured by this. The best result we have obtained in England after trials and competitive results,

including loss in feeding mains, dynamo friction of engine, is a loss of 18 per cent. from the calculated i.h.p. in cylinder. Instead of 1,000 h.p., therefore, 1,200 would be the number; 1,240 would not be excessive, and 210 h.p. is not an excessive reserve. The question of cost of mains he must decline to discuss with Prof. Forbes, because he has based everything on the system of overhead mains, and overhead mains will never be allowed as a permanent large distributing system in this country. He had now, he thought, answered all the objections. Figures were worth more than opinions, and on nearly all grounds the B.T. system is overwhelmingly superior. No doubt the cost of transformer systems might be reduced. The Grosvenor Gallery Company have been very silent about their coal bill, but from what we can learn their experience has been that the consumption of coal for each e.h.p. was nearly 18lb. of coal; it should be more like a quarter of this. He hoped to have the opportunity at no distant date of setting before them full facts and figures on the consumption of coal. The battery system, he maintained, then, is less expensive, needs smaller plant, need not be always running, the labour is very much less, the likelihood of breakdown at the height of supply practically abolished. When he put these together, he thought he had prepared a very formidable array of figures against the transformer system. If at some future date someone can give further figures and a different result, he should be very pleased to listen to them. In conclusion, Mr. Crompton said he would like to bear witness to the fact that Prof. Forbes had drawn attention to the subject of the great advantage of bare underground cables at much about one and the same time as himself.

Lord Crawford said he thought Mr. Crompton had been misinformed on the point of the coal consumption at the Grosvenor Gallery. His informant had probably omitted the decimal point in his statement of 18lb. of coal per e.h.p.

FIRE RISKS INCIDENTAL TO ELECTRIC LIGHTING.

After Mr. Crompton's reply to the criticisms on his paper, the discussion on Mr. Preece's paper was continued by **Mr. Musgrave Heaphy,** who said: At the last meeting I asked and obtained permission to make a statement this evening as to the reason the sittings of your committee on the office rules were interrupted, for I felt the account given by Mr. Preece unintentionally conveyed an erroneous impression. Had it not been for that remark I should not have spoken at all, for obvious reasons. In May last a committee of your council was formed to draw up a set of rules from the rules of 1883. Communications were opened with the Phœnix on the matter, the result being that a tentative agreement was arrived at, that in order to settle once for all any difficulties as to rules for the future, the Telegraph rules and the Phœnix rules should come out under the same cover, the cover to contain no mention of the Phœnix. The first portion of the pamphlet was to contain general rules and principles for installations drawn up by your committee; the second portion of the pamphlet the Phœnix detailed rules for installations, there being an acknowledgment clause that these detailed rules were the Phœnix rules. In making certain that there was nothing in the Phœnix rules that would be objectionable, four gentlemen of your committee were to form a sub-committee, and to go over them, clause by clause, word for word, and in the event of our not agreeing, the arrangement was to come to an end. These gentlemen were to be men *practically* acquainted with the difficulties of electric light installations. They were Mr. Preece, Mr. Siemens, Mr. Crompton, and Major-General Webber, and it is impossible to thank those gentlemen too much for the time and care and labour bestowed, especially Mr. Preece, and I am sure that had the matter been in their hands I should not have been so unfortunate as to trouble you this evening with my remarks. We had many sittings at the office of your society without the slightest hitch or difficulty of any kind, and the Phœnix rules were unanimously approved after certain verbal alterations had been made, and a few other very slight variations. The acknowledgment clause was then framed and *agreed* to. The sub-committee then revised their general rules; with these I had nothing to do. These general rules were *not* those that your committee has recently issued. [Here Mr. Heaphy showed the pamphlet printed]. I thought the matter was now at an end, so far as I was concerned, when I received a letter asking me to attend your committee to explain certain rules. I thought this strange, as the matter had been so thoroughly gone into by the sub-committee that they would be conversant with every point; but I accordingly went, when, to my surprise, the first thing I heard spoken was the acknowledgment clause called into question, with an intimation that instead of the detailed rules being acknowledged as the Phœnix rules they should be called rules *based* on the Phœnix. I also found that the whole of the Phœnix rules were to be gone over again—not the original Phœnix rules in the Phœnix cover, but the very slightly altered Phœnix rules that were in the cover of the Telegraph-Engineers. What, then, was the position of the Phœnix? Their rules might again have been slightly altered, verbally, and the acknowledgment clause altered objectionably, and all copyright lost; perhaps the very name of Phœnix might have been expunged in the next edition altogether, and what remedy would the Phœnix have had? None. If it objected, the answer might have been: The detailed rules had been drawn up with the consent of your own representative, sitting as one of the committee; you cannot now refuse to recognise these rules, nor object to the acknowledgment clause whatever it may be. Gentlemen, the Phœnix Fire Office after a time might have been entirely deprived of its rules. I only say, might. What was the only course open to the Phœnix? What would any of you have done? Why, what the Phœnix did—say that unless the acknowledgment clause was to stand as agreed upon, in the event of your committee being satisfied with the rules, it must retire from all negotiation. It then writes this letter: there is not time now to read it, but I do hope that your committee will allow it to be printed in its proceedings. I attended the next meeting, when your committee declined to give me any information until the sittings on the Phœnix rules in their pamphlet had been completed, I to sit with them. Gentlemen, I had nothing left but to retire. Several gentlemen on the committee asked me to stop, saying I could reckon on their support. That I knew; but when I said that you might possibly be out-voted by others of a different opinion, the reply was, "Yes, that might be so." I do not wish for one moment to impute that your committee would have done anything that it did not consider right and honourable. I do not wish to cast the slightest imputation upon any one of them; but there are often two different ways of regarding the same thing, and what would seem perfectly fair and right from one view would be felt as a bitter wrong and injustice from another. Let me give you an instance. A speaker, last Thursday, in this room, actually stated in effect that, because some of the clauses in the Phœnix rules which were brought out in February, 1882, were then similar to certain rules in America, therefore, there is no right to copyright in the present Phœnix rules, notwithstanding all the original thought and labour bestowed upon them to make them perfect; that an installation put up by them is a different one in this country from installations elsewhere; and that thought treating upon systems of lighting undreamed of six years ago ought not to be monopolised by anyone who chooses to appropriate it. Gentlemen, I can assure you that the Phœnix has always been, and is now, most willing and anxious to do everything that is just and right, but it does consider that fairness should be shown to it in return. Gentlemen, you know what injustice is. You have had to feel the tyranny of Chamberlain's Act; but that Act is mercy itself compared with the one that is now sought to be imposed. You had 21 years allowed you before your work was confiscated. The Phœnix rules are not to be granted any time at all. I will never believe, gentlemen, that you will be a party to such an injustice.

Mr. Hubert rose to explain upon one point. On the last occasion there was mention made of the minimum of electric resistance allowable in insulated covering of electric cables. Mr. Preece had advocated a minimum of total leakage, and had specified $\frac{1}{5000}$th of the total current—that is to say, a leakage enough to light one lamp, if the installation was for 5,000 lamps. The fire offices wanted to have the best practical rule, and he did not think that this was as good a method of testing as by resistance. Those in the trade could easily measure to so many meg-ohms in resistance, and, of course, in an installation of 5,000 lamps, one lamp would be lighted by the leak. That would be plain. But what he wished to ask about was the case of a small installation, such as they often had to deal with, where, perhaps, only 10, 20, or 30 amperes were used. He would like to ask experts if they could readily and correctly measure, say, $\frac{1}{5000}$th of 15 amperes.

Lord Crawford said: When rules were multiplied weaknesses also multiplied, for each rule might become a weak point. Practical men of high moral tone would not take advantage of these weak points. Contractors who were not so particular would do so, and the installation, while still technically complying with the rules, might still be unsatisfactory. The Phœnix Fire Office was the first to take the matter up from the point of view of fire risks; the rules published in the *Times* newspaper for 1882 were the first basis upon which they had proceeded. Other offices remained inert. To them electric lighting was an unknown factor; they refused to have anything to do with it for fear they might burn their fingers. We are all greatly indebted to the Phœnix for stepping into the breach and grappling with the question firmly and nobly. They have spent much time and trouble, and have advanced with every advance of science. We have found at the Grosvenor Gallery the Phœnix rules as satisfactory as any that could be framed, and we have had the largest experience in London. We are putting on lights at the rate of ten houses a day; the wiring of these is all supplied by the customers themselves, and we have naturally to insist upon such work as shall not endanger our system or our credit. We have come to the definite determination to have all such installations wired according to the Phœnix rules, and when they had not been so wired, or had been passed by other offices, we insisted upon them being inspected and passed again under the Phœnix regulations before the current was turned into the house. We have a great stake in this matter, and any public building suddenly failing through fault of the contractors is at once laid to us. A man cannot get the best work done unless he is able to pay the price for good workmen, and the sooner the bogus installation-mongers are stamped out the sooner will electric lighting take its proper place as a necessity in London.

Mr. Wharton said he did not think any alteration was required in the rules at present. There were two parties principally interested to consult—the contractors and the fire offices. As a contractor, he did not want any alteration. Fires have not occurred in installations wired under the rules, and although Mr. Heaphy was strict, he was not too strict, and was always open to modification if real necessity were shown to him. Did the fire offices require any alteration? He did not think so. Up to that moment he believed he was quite correct in saying not one fire had occurred in installations passed by the Phœnix office. [Mr. Heaphy: Not one.] These were therefore, the parties most concerned, and the rules were, he thought, now as good as they can be, and any alterations could only be for the worse.

Mr. Shoolbred thought a good deal of feeling had been imported into the discussion which was not within the scope of the paper. It was to be understood that these rules were not to supersede those of the fire offices, but to definitely state the scientific principle from which such rules could be properly derived.

Mr. Marlborough Pryer, director of the Sun Fire Office, chairman of the Fire Offices Committee, said he had objected to the statement upon the copy of the rules, that they were "accepted by the leading fire

offices," because that was not the fact; there were many of the leading fire offices who had not accepted these rules. He objected to the necessity, evidently insisted upon in these rules, that every house which was fitted with electric light should be personally inspected by the fire office inspectors. He did not think there was any more necessity to inspect every individual house, than with gas. It was not the business of fire offices to trouble householders continually about the electric light. If they had to have an army of inspectors the premiums would have to be raised to recoup themselves. They therefore did not accept these rules, which were drawn up so as to require the inspection of each installation. They wished rules that will sufficiently cover all cases without individual inspection.

Mr. Rawlins said he hoped they would be able to produce rules which would apply under all circumstances, which were not "copyright," for which there was no charge, and which did not require a paid interpreter to interpret them for actual use in installations.

Mr. Hammond said that he would like to take the opportunity while so many representatives of the fire offices were present to tell them that what all the electrical engineers were looking forward to from them was not only no advance, but a reduction. He thought they should allow a 15 per cent. reduction on all houses lighted by electricity.

Mr. Preece, in reply, said his hope in reading the paper was that in bringing before the society a series of experiences in cases of failure and accident, it would lead other men of practical experience and scientific knowledge to give other instances which might have led to some further development of the subject. Unfortunately, quite a number of subjects quite foreign to the risks incurred in electric lighting had been imported into the discussion. He had no wish to refer to all of these. There was one thing he would like to point out, that it had been said that the risks incidental to electric lighting was a question solely between the fire offices and the contractors. It seemed to him the chief risk was with a third party—the users. The chief regard should be to protect the users from the rapacity of certain contractors. Of course, there were contractors and contractors; but with competition so severe there were many contractors who will take all means of making a profit who will even send orders to manufacturers which respectable manufacturers would not care to execute. This discussion was another illustration of the old proverb, "a man convinced against his will is of the same opinion still." He did not think the discussion either on the accumulators and transformers, or on the fire risks, had converted a single man who had listened. It was true they had passed several very pleasant evenings, more pleasant, perhaps, than even at theatre. There was just one point which should be referred to with regard to the combined rules in one cover referred to by Mr. Heaphy which they had had flourished before them that evening. Those rules were not printed by the Society of Telegraph-Engineers at all, but were printed in that form by the Phœnix Fire Office. With regard to the further intention of bringing the fire-offices and the telegraph engineer together, he was always quite ready to do all he could in the matter. In reply to the question as to whether it was possible to measure one-five thousandth of 15 amperes, he did not suppose there was any electrician in the room who could not measure a current of three milli-amperes which was one-five thousand of 15amperes—it was one of the simplest every-day problems of an electrician. Mr. Shoolbred had asked him a most interesting question, that with regard to the heating capacity of wires. This question was one which had occupied him more than any other during the last five or six years, and had dealt with this in recent papers before the Royal Institution and the British Association. In the last paper read a set of constants were given, which will enable anyone to find out what current will fuse any wire, of any diameter, of any usual material. This rule he was endeavouring to apply to insulated electric light wires, and hoped to give the result before long. Prof. George Forbes had given a table on which the radiation at normal tables was calculated, and Mr. Robert Sabine not long before had done the same thing, but for this general rule we cannot determine the heating of electric wires; and there was Mr. Macfarlane's experiments on Sir Wm. Thomson's laboratory in Glasgow, who showed that "emissivity"—that is, at the rate of loss of heat per unit area of a copper sphere—could be expressed by a constant. There was every reason to believe that a similar constant was applicable to copper cylinders. The experiment was made with brightened and blackened copper spheres. We may have experiments which will give us radiation from bare and covered cables, and enable us to calculate the exact loss from heating with any given current. In conclusion, he could only express regret that more had not come of his idea of bringing out experiences of actual risks connected with electric lighting, but the question remained to be discussed, and he hoped it might at some future time be brought forward by some more competent person.

PROVISIONAL PATENTS, 1888.

MAY 11.

7035. **An electrical coupling.** William Edward Langdon, Telegraph Department, Midland Railway, Derby.

MAY 12.

7083. **Improvements in electro-medical batteries.** Thomas Wm. Ford, Ash Villa, Oxford-road, Clewer, Berkshire.

7102. **Improvements in apparatus or appliances for automatically obtaining light by electricity applicable for lighting cigars, pipes, and the like purposes.** Charles Henry Baines, 33, Chancery-lane, London.

7105. **Improvements in compasses.** William Cooper Cooper, 24, Southampton-buildings, London, W.C.

MAY 14.

7111. **Improvements in electrical couplings, partly applicable to other purposes.** John Hubert Davies, 3, Burry-terrace, Westbourne-square, Paddington, W.

7131. **Improved apparatus for measuring and regulating electric potentials and currents.** Sir William Thomson, 115, St. Vincent street, Glasgow.

MAY 16.

7256. **An improved combined holder, switch, and cut-out for electric glow lamps.** Frank Rowling, 2, East Parade, Leeds, Yorkshire.

MAY 17.

7301. **Improved apparatus for measuring and regulating electric potentials and currents.** Sir William Thomson, 115, St. Vincent-street, Glasgow.

7308. **Electric date and time printing stamps.** Charles Adams Randall, 19, St. Swithin's-lane, London, E C.

7321. **An improvement connected with accumulator jars or other receptacles for holding plates of metal or the peroxide plates and negatives for electrical storage batteries.** John Kent and Frederick John Beaumont, 9 and 10, Railway Approach, London Bridge, S.E.

7332. **Improvements in and connected with conductors of electricity.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

7333. **Improved electrolytes for electric batteries.** Robert McKenzie, 47, Lincoln's-inn-fields, London. (Henry Weymersch, France.)

7355. **An improvement in field telegraph and other similar conductors.** Richard von Fischer Treunfeld, 28, Southampton-buildings, Chancery-lane, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MAY 10, 1887.

6809. **Improvements in electric bell indicators.** John Eshelby and Edwin Eshelby, 5, Eden-quay, Dublin.

MAY 11, 1887.

6918. **Improvements in telegraphy.** William Edward Gedge, 11, Wellington-street, London. (Auguste Claude, France.)

MAY 13, 1887.

7042. **Improvements in electric arc lamps.** Frederick George Chapman, Fred Mitchell Dearing, and William George Chapman, 1, Queen Victoria-street, London, E.C.

JULY 13, 1887.

9829. **Improvements in dynamo-electric machines.** Thomas Stanley, 8, Quality-court, London.

JULY 21, 1887.

10,195. **Improvements in dynamo-electric machines.** Joseph Platt Hall, 4, Mansfield-chambers, 17, St. Ann's-square, Manchester.

JULY 30, 1887.

10,575. **Improvements in instruments for electric measurement.** Walter Emmott and John Hall Rider, The Northern Telegraph Works, Halifax, Yorkshire.

NOVEMBER 16, 1887.

15,717. **Electrical date and time stamp.** Charles Adams Randall, 7, Alfred-street, Brompton.

SPECIFICATIONS PUBLISHED.

1887.

6120. **Miners' safety lamps.** W. Patterson. 8d.

6204. **Induction coils and transformers.** W. J. Muller. 8d.

7553. **Dynamo-electric machines.** F. George. 4d.

8181. **Testing submarine electric telegraph cables, &c.** H. A. Taylor. 8d.

8708. **Fixing telegraph posts.** J. Oppenheimer. 8d.

8710. **Electrical apparatus for firing ordnance.** T. Nordenfelt. 8d.

8855. **Electric piles, &c.** E. Julien. 11d.

10,963. **Measuring electromotive force and power.** J. A. Fleming and C. H. Gimingham. 11d.

13,970. **Automatically administering medical electricity to the human frame, &c.** M. Nightingale. 8d.

14,415. **Miners' safety, &c., lamps.** W. H. Edwards and C. Britton. 6d.

1888.

2515. **Dynamo-electric generators, &c.** J. Feaveryear. 8d.

3835. **Telegraphic apparatus.** H. P. Copeland. 8d.

3995. **Galvanic batteries.** H. H. Lake. (Walter.) 8d.

4274. **Storage batteries.** W. P Thompson. (Gibson.) 6d.

4275. **Storage batteries.** W. P. Thompson. (Gibson.) 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday-
3 Jan.	4%	Afr'can Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼
12 Feb.	2/0	— fully paid	5	4
26 April	1%	Anglo-American	100	38¼
26 April	2%	— Pref.	100	64
12 Feb., 85...	5/0	— Def.	100	13
28 Mar.	3/0	Brazilian Submarine.........	10	12½
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	8⅞
12 April	2/6	Eastern	10	11¾
12 April	3/0	— 6% Pref.	10	14¾x
1 Feb	5%	— 5%, 1899	100	111
26 April	4%	— 4% Deb. Stock	100	108
26 April	3/6	Eastern Extension, Australasia & China............	10	13
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	103½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5⅞
12 April	3/0	— 6% Pref.	10	13⅞
30 April	5/0	Great Northern	10	14½

Dividend.		Name.	Paid.	Price. Wednesday
1 Mar.	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17
11 May	37/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	6
16 Mar.	5%	Maxim Weston	1	⅛
26 April	2½	Oriental Telephone	11	$\frac{7}{16}$
26 April	4/0	Reuter's	8	8½
......	...	Swan United	3½	2¼
15 Feb.	15½%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40⅛
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	15⅛
......	...	West African	10	5
1 Mar.	5%	— 5% Debs.	100	92¼
29 Dec.........	6/0	West Coast of America ...	10	6⅛
31 Dec.	8%	— 8% Debs.	100	117
11 May	9/	Western and Brazilian......	15	$10\frac{3}{16}$x
11 May	6/10½	— Preferred	7½	6⅝
11 May	2/1½	— Deferred..................	7½	3⅞x
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	$1\frac{1}{16}$
30 Nov.	...	— 6% 1st Pref.	10	11¼
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 May	7%	West Union of U.S.	$1,000	123
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Mar. ...	£37,331	+ £1,376
Brazilian Submarine	W. May 18 ...	£5,326	...	Great Northern	M. of Apl. ...	21,400	...
Cuba Submarine	M. of Apl. ...	3,700	+ £736	Submarine	None	Published.	
Direct Spanish......................	M. of Feb. ...	1,800	+ 119	West Coast of America	M. of Apl. ...	4,405	...
— United States	None	Published.	...	Western and Brazilian	W. May 18 ...	3,561	...
Eastern..............................	M. of Apl. ...	51,582	+ 8,446	West India and Panama	F. April 30 ...	3,268	+ 231

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Dalmatia Mining and Electric Power Company.—The Dalmatia Mining and Electric Power Company, Limited, office is at 3, Queen-street.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended May 18 were estimated at £5,326.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the week ended May 18, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,405.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company, for the half-month ending May 15 were £2,802, as compared with £2,297 in the corresponding period of 1887, showing an increase of £523.

Protean Battery Syndicate, Limited.—This syndicate was registered, with a capital of £5,000 in £10 shares, to carry on business as electricians, and for such purposes to adopt an agreement of February 2nd, between Mr. W. Kingsland and Mr. M. Norsworthy. The subscribers include Mr. M. Norsworthy, Old Broad-street; Mr. E. R. Gibson, Lloyd's; Mr. P. Lloyd, Old Broad-street; and Mr. J. Davies, Finsbury-square. Registered without special articles.

Government and the Telephones.—The war on this question is being kept up in the columns of the *Financial News*. The aim of the paper, and in fact most of the financial papers, seems to be to attempt to put some backbone into the management of the United Company. The *Economist* recently condemned the colourless and manimate policy of the United, and is congratulated upon this fact by the *Financial News*. During the past week the columns of the latter have been opened to a correspondence on the subject, in the course of which Mr. A. A. Campbell Swinton says:—"The Post Office is not, however, the only competitor with whom the United and its subsidiary companies will have eventually to deal. Even at the present moment, and in spite of the virtual patent monopoly enjoyed by these companies, the most important of the two telephone exchanges existing in Sheffield is a private venture entirely distinct from and out of the control of these companies, and when the United Company's Bell and Edison patents have expired (the Bell patent expires December, 1890, and the Edison July, 1891), or when, what is perhaps more probable than the United Company and it supporters find it convenient to assume, the Equitable Telephone Association is successful in the litigation now pending, and brings these patents to a premature end, or at all events establishes the freedom of its own instruments from their patents, there will be nothing to stand in the way of a direct competition in which the United and its subsidiary companies will be immensely handicapped." The United has made a move in promoting a company with a capital of £10,000,000, evidently with the intention of harrassing Government action by-and-bye, but we doubt very much if the object will be attained. There are some business heads in the Postal Telegraph Department that can give the wire pullers of this huge company a good many points without losing the lead.

NOTES.

Telephones in America.—The United States has 341,070 telephones in use. The net profit from these in 1886 was 4,150,000 dollars. The extent of the wire is 128,231 miles.

French Novelties.—Descriptions of a new type of arc lamp, by M. Cance, taking three amperes, and of a small pocket photometer, by M. Mascart, were read at the Société Française de Physique.

Accumulators for Bremen.—A very large storage battery will be provided for use in the central station at Bremen by Messrs. Spieker and Co., of Cologne, who have the contract for lighting.

Magnetic Iron-Separator.—Enquiries are made for supply of these machines, which have been exhibited in one of the exhibitions lately. We shall be glad to hear if they are manufactured for sale.

Electric Power Printing.—A printer who has tried states that there is no other power to be compared to electricity for running printing presses as regards economy, cleanliness, and easy management.

Telegraph-Engineers Students' Meeting.—A paper will be read on Thursday, June 7, at the students' meeting, "On Belts and Belt Driving for Dynamos," by J. N. Cooper; Prof. J. Perry, F.R.S., in the chair.

Schanschieff Battery.—The Schanschieff Battery Company, Limited, have had an injunction brought against them on the ground of prior invention, and have had to suspend practical operations until further settlement.

Glass Sleepers.—We understand that a company is being formed for utilising toughened glass for railway sleepers, in which Mr. Fred Siemens is interested. These should be used when our electrical tramway companies get to work.

Glass for Electric Light.—A great deal of glass work for shades, reflectors, &c., for electric light use is imported from Germany. Hirsch, Janke, and Co., of Berlin, and Campe and Co., of the same city, are two chief makers.

Eastbourne.—At Eastbourne the light is so much appreciated that the authorities are paying £35 per annum for each arc lamp of 1,000 c.p., burning up to 11.30 p.m., being at the rate of £70 or £80 per annum for all-night lighting.

Elwell-Parker.—Two large additional shops have recently been built by Messrs. Elwell-Parker at Wolverhampton, with a view to meeting the increased demand for dynamos and batteries, and additional engine power is also being put down.

Paris.—According to the *Moniteur Industriel*, the Compagnie Française d'Eclairage Electrique is to be wound up by direction of a general meeting of the shareholders held in Paris. MM. Clerk and Rousseau are nominated liquidators with full powers.

Small Dynamos.—We are often asked where a small type of dynamo for experimental or research purposes can be obtained. Messrs. J. C. Hauptmann and Co., of 11, Kornerstrasse, Leipzig, supply a good type of small dynamo for these purposes.

Electric Shoeblack. — An electric boot-blacking machine is to be seen in New York, in which a brush is rapidly revolved in a non-rotating handle. The whirling brush brings the shine in one-tenth the time of the old vibratory elbow method.

Paris Electrical Laboratory.—La Société Internationale des Electriciens have asked permission of the municipal authorities of Paris to have the gratuitous use of part of the ground of the ancient Rollin College, for setting up a central electrical laboratory.

Newcastle College.—The new College of Science, Newcastle-on-Tyne, is making progress, though it is not expected to be ready for some considerable time. Prof. Garnett, well known as a skilled educator and scientist, is the principal of the new college. The situation of the college is near that of the recent exhibition.

Catalogue Received. — We have received the catalogue of Messrs. Robertshaw and Sunderland, Victoria Electrical Works, Halifax, containing a list of electrical requisites—bells, detectors, indicators, lamp fittings, repeater and needle instruments. A linesman's tool box, fitted with a complete set of tools necessary for electrical fitting, is also included.

Waltham Watch Company.—This company has decided to introduce the incandescent light throughout its premises. The installation will be a small central station of itself, and will be one of the largest private plants in the world, comprising a total of nearly 5,000 lamps. The system selected is that of the Mather Electric Co., of Manchester, Connecticut.

Motors at Work.—Electricity is the motive-power for several establishments in Oakland, Cal. It runs a coffee-mill for the New York Tea Company; moves a score of sewing-machines for M. J. Keller, manufacturer; rotates an ice-cream freezer for O. C. Coiner; wiggles a sausage machine for Fred. Becker, and is to give power to the presses in *The Evening Tribune* building.

Fire through Snow.—The Pittsburgh Electric Railway Company, finding its line blocked with snow, ordered a large quantity of salt to be thrown along the line so as to dissolve it. The conductors, working at a difference of potential of 500 volts, were carried in wooden troughs, and the melting snow and salt speedily established a circuit between the conductors, with the result of setting fire to the troughs.

Tenders Wanted.—The Poole Town Council invite tenders for lighting the borough by gas, electricity, or other means, for one or three years from 1st September next. Particulars from the Town Clerk.—Also, Mr. J. Bertwistle, F.S.I., architect, Jacketts-street, Blackburn, is inviting tenders for electric light installation for new weaving shed, Ribchester, near Blackburn. Tenders must be sent by June 9.

Dangers of Gas.—A terrible explosion of a gasometer is reported from Montreal. The whole of the gas works were completely destroyed, and seven persons killed; thirty persons were injured, many seriously. A similar accident has occurred at Gorichem, Holland, where the gas escaping caught fire, and the explosion which followed totally destroyed the purifying house. One person was killed, and three are in a precarious condition.

A Good Word for the Telegraph Wires.—A large piece of cornice in Chicago fell last week, and fortunately caught and was held suspended on the telegraph wires, and only fragments struck those underneath, who otherwise might have been killed. At a newspaper office

at Des Moines, Indiana, a fire broke out, and the workmen, who found the stairway burnt out, climbed along the telegraph wires and slid down the post, amid the cheers of the spectators.

The Phonograph.—Edison's phonograph, in its improved form, has been launched with great *éclat* in New York, and long descriptions appear in the New York papers. Mr. E. T. Gilliland, Edison's colleague in the matter, read a paper, and numerous interesting experiments were made. It is worked by a small electro-motor; the usual size will record a continuous speech of eight minutes' duration, about one thousand to twelve hundred words. The price is 85dols., and large orders are booked.

Renard Battery.—At the Sociétés Savantes M. le Capitaine Renard exhibited a single fluid battery, which he claims far surpasses all previous batteries in its results and cost of maintenance. The first cost, however, is greater, the cells being of silver, with platinum thickly deposited outside. It is worked with a chloro-chromic solution. The battery is remarkable for the smallness of its weight for the work given, and also for its constancy. He proposes using these batteries for aerial propulsion in the French army.

Diamagnetism.—At the meeting of the Société Savantes of May 14, M. Mascart presented some observation upon the theory of diamagnetism, brought forward by M. Blondlot, of which we gave an abstract last week, in which he said that the conclusions arrived at were not justified. M. Becquerel, however, had not the same opinion. He thought that M. Blondlot's experiments coincided with the hypothesis he had maintained since 1850—that magnetic and diamagnetic phenomena were mutually dependent.

Leamington.—The lively discussion last week seems to have aroused the company to further action. It is announced that they have decided to put down a large supply of accumulators from which customers would be supplied as a protection in case of accident to machinery or dynamos. After June 1st, the supply will be continuous night and day. This will not alter the street lighting, however, of which chief complaint was made, and many persons think that a change of the kind of lamps used in the streets will be satisfactory.

Wimbledon.—Notice is given in the *Gazette* of the 25th inst. of the application to the Board of Trade of the Wimbledon Local Board for a licence to supply electricity under the Act of 1882, to break up streets and railways, &c. Copies of the draft of the licence can be seen at the office of the Local Board, Broadway, Wimbledon, and at the office of the solicitor for the licence, W. H. Whitfield, Esq., 22, Surrey-street, Strand, W.C. Representations to the Board or objections must be sent to the Board of Trade within two months from 5th May, 1888.

Enghein-les-Bains.—At this station, on the Northern Railway Company of France, the petroleum lamps hitherto used are to be replaced by 90 incandescence lamps worked by 160 accumulators on the Laurent-Cély system. These accumulators are to be charged by a dynamo at the works of La Chapelle, through a copper conductor 24 kilometres in length, and 5 milimetres in diameter. A French contemporary gives the E.M.F. of the dynamo as 700 volts, which would apparently render it ill-adapted for the purpose in view. The enterprising railway company above mentioned expects to realise a saving of 33 per cent. by the substitution of electric power for oil.

Zipernowski-Deri Transformers. — Since 1887 Ganz and Co., Buda-Pesth, have installed, says *L'Electricien*, a number of distributing centres, using the Zipernowski-Deri-Blathy transformers, which are acting perfectly, and show the excellence of the system. At Montevideo 450 h.p. is transformed by their means, at Terni 450, at Rome 1,200, at Livorno 450, at Saint Paul 300, and at Odessa 300. The station at Rome consists of two alternate-current machines of 600 h.p. each. Several further installations have also been undertaken this year. These transformers are spreading more and more in practical use.

Electric Launches.—The propelling of boats by electricity is receiving quite a boom in Massachusetts. The Electric Accumulator Company is in daily receipt of many inquiries of this nature, and has just installed an accumulator plant, to be used with a small Sprague motor, in a rowboat at Attleboro', Mass., belonging to H. K. Sturdy. The same company has also fitted the beautiful new yacht "Sagamore," belonging to John W. Streeter, with an accumulator plant, to be used in connection with the Edison system of incandescent lighting. The yacht was built by the New England Shipbuilding Company, and is shortly to start on a cruise around the world.

Amsterdam.—The central station of electric lighting now actually at work at Amsterdam presents certain interesting features. The station being situated very near the places to be lighted, the engineers have passed over the high potential system and alternate current system, and instead have adopted the system of distribution at 100 volts. The current is furnished by two dynamos driven at 100 revolutions only per minute, by a direct driving steam engine of 240 h.p., by this means obviating any risk of stoppage from gearing or belts. In addition, the attendance required is very small. The installation has been carried out by the Helios Company of Cologne.

Telegraph Clerks.—The seventh annual conference of the United Kingdom Telegraph Clerks' Association was held in Leeds on Saturday, delegates being present from all the large provincial offices. The financial condition of the association was reported to be in a much improved state. By a special resolution, the insurance subscription was reduced from sixpence to twopence per week. A resolution to petition the Postmaster-General on certain grievances was negatived, it being considered desirable to wait the result of the Civil Service Inquiry. The system of annual leave was declared unsatisfactory. The conference supported the Sunday pay agitation.

Dust on Electric Wires.—The accumulation of dust on electric light wires is explained by Mr. G. A. Nellis as follows :—The magnetic whirl round an electrical conductor acts upon the atmosphere, which is highly magnetic, oxygen being the most paramagnetic nitrogen, and the most diamagnetic of gases. The attraction of the oxygen will cause some of the dust to adhere to the wires; the repulsion of the nitrogen will cause the ceiling near to be blackened. This accumulation of dust is more noticeable on the positive wire of a continuous current system, and is absent on a wire conveying an alternating current, which may be thus easily distinguished by its comparative cleanliness.

Hamburg Central Electric Lighting Station.—The firm of Mr. S. Schuckert, of Nuremberg, has been entrusted by the State of Hamburg with the installation of the Hamburg Central Electric Lighting Station, for which about 24 prominent firms had tendered. This central station is intended to supply about 20,000 incandescent

lamps, and an enlargement is in contemplation. During the course of this year a first installation of 10,000 lamps must be completed. According to the calculations issued by the experts of the Finance Committee, it is expected that the undertaking will prove a financial success, 6 per cent. on the capital invested being the estimated net profits.

M. Desroziers' Dynamo.—At the Sociétés Savantes M. Desroziers exhibited a dynamo on which he has been engaged for some years at the works in Bréguet. It is of the disc type, the advantage of which is great linear speed of revolution, avoidance of loss of work in alternations of magnetism in the field-magnets; the conductors are bare and well ventilated, and yield a very large current per unit of section. M. Desroziers gave figures which showed a produce of 14 amperes per square millimetre, which is enormous compared with ordinary types, these rarely yielding over six. The air space in this machine was considerable. Allowing for clearance of the armature, nevertheless, the field obtained was nearly 10,000 units.

Accumulator Tests.—The tests undertaken by the Electrical Institute at Venice by Prof. von Waldenhofen have now terminated. They were instituted to try the merits of various accumulators made by Fahrbaky-Schenk, Reckenzaun, and Julien, especially with regard to their application to tramcar work. Tests were taken of the E.M.F. on open circuit, the density of the fluid, and the difference of potential during work. The comparative efficiency of the batteries is as follows: Reckenzaun, 89·3 per cent. return of quantity, 80·85 per cent. of the total energy, calculating difference of potential, charging and discharging; Julien, 89·7 and 83 per cent. respectively; Fahrbaky-Schenk, 91 and 78·5 per cent.

Carbon Factory.—One of the most important carbon factories is Mr. Ch. Schmelzer's at Nuremberg, established in 1884. Since its commencement the undertaking has been remarkably prosperous, and at present about 75 workpeople are employed. After many costly experiments, Mr. Schmelzer has succeeded in constructing most efficient pressing machines, especially hydraulic pressing machines, working with a normal pressure of 600 atmospheres, and the machines now in operation are capable of producing 25,000 meters of carbon rods per day. Two gas generators furnish the gas for two furnaces, which comprise about 30 cubic metre available space in 40 compartments. The factory is lighted by 20 arc lamps, fed by a Schuckert dynamo.

Automatic Leak Indicators.—In his paper on "Installation Breakdowns," read before the Old Students' Association, which we reproduce this week, Mr. Reginald J. Jones makes a suggestion which we think may possibly be worthy of further and practical consideration. He mentions the fact alluded to by Mr. Crompton, that an installation whose insulation resistance is very high, after actual use often deteriorates considerably in this respect. Mr. Jones suggest the permanent presence in the circuit of what he terms an automatic leak detector, which shall give prominent notice, by alarm bell or other method, when the insulation resistance falls below a certain point beyond which the leakage might endanger the system. We shall be interested to see whether this original suggestion will be carried out.

Central Station at Paris.—The Paris Compagnie Parisienne d'Eclairage Electrique, whose central station is installed at the Place du Panthéon, are proceeding to public trials to learn if they may distribute the light in the Quartier des Ecoles, where it has been opposed for some time. The installation at present comprises three "Brown" dynamos, 110 volts, and 360 amperes, with a speed of 360 revolutions per minute. Each of these dynamos is driven direct by a quick speed steam engine. Collet boilers are used. A main switch-board, well grouped and easily supervised, allows a regular light to be assured. All the material has been installed so rapidly that the machinery had only to be placed in position, everything being sent mounted and ready to work from the works of the Œrlikon Company, near Zurich. The Sainte-Geneviève library will be shortly lighted.

The Distribution of Motive Power.—This application of electricity is more or less general among the central stations of America, by the use of electro-motors, not only for ventilating, knife-cleaning, &c., but also for heavier work, such as printing. The employment of small electro-motors for domestic use does not seem to have received such a development as might be expected in this country, though no doubt when central station distribution for light is more general, these will be used. At Salsburg the employment of electricity for use with motors in the daytime is greatly extending, many motors of the Siemens' type giving $\frac{1}{16}$ to 1 h.-p. have lately been put in. These work at a speed varying from 1,200 to 2,500 revolutions per minute, and are used for ventilating kitchens and billiard-rooms, and for various domestic purposes.

New Filament from Russia.—We notice an account from Pittsburgh, U.S., of a visit from M. de Routhowsky, secretary of the Russian Legation, to Mr. Geo. Westinghouse, jun., to bring before his notice a new filament invented by a fellow-countryman, on whose behalf he has concluded an important contract with Mr. Westinghouse relating to incandescent lamps. The discovery relates to a filament that is capable of standing so high a temperature as to give two to four times the light with the same power as the Westinghouse or Edison lamps. It is said the filament will give more light for the horse-power than two arc lamps, and it is hoped to be used instead of arc light systems. The effect on incandescent lighting would be to double the capacity of existing plants, while saving 10 per cent. in fuel. If Mr. Westinghouse has taken the matter up we may expect to hear more of the discovery—meanwhile rumour requires confirmation.

Electric Tramways.—A letter from Lord Bury appeared in the *Birmingham Daily Post* of the 26th ult., in which he says that electricity as a motive power for tramways is not, as a correspondent imagines, "a pleasant vision and a vision afar off," but that it may be seen in actual operation by anyone interested in the subject at Canning Town, London. Lord Bury is chairman of the Electric Traction Company, New Broad-street House, which has a contract with the North Metropolitan Tramways Company for working a portion of their line—experimentally at first, and afterwards to be extended to the rest of their system. The experimental car is now at work with complete success, and he invites persons interested to inspect the system. He states that they are prepared to equip tramways, which in point of economical working will compare favourably with horses, and that the system is in actual operation, and suggests that the vision, however pleasant, is not a distant one.

Mouldings.—Not the least important question where artistic electric lighting has to be considered is that of mouldings for the wood casing containing the wires. Of

course, in running the conductors for an installation, it is quite easy to bring in hundreds of yards of ordinary white wood moulding and run it, *à tort et à travers*, all over the building; but in a good house it is often very necessary to consider the decorative effect of the moulding where the wires are run, so that they may be both harmonious with the surroundings, and not noticeably prominent. Considerable attention to this detail of electric lighting has been given by Mr. F. Geere Howard, Cleveland-street, W.; and we have also lately received a very well got up pamphlet from Mr. Samuel Elliott, Albert Moulding Works, Newbury, containing sections of high-class mouldings suitable for this purpose. The pamphlet contains some five or six hundred designs of mouldings, plinths, cornices, picture rails, &c., from which, in fitting a house, electrical engineers might select to suit the requirements.

Windmill Electricity. — The idea in America of utilising wind-power by the aid of storage batteries for the purpose of light, heat, and power is very soon to be put to a practical test in a building about to be erected in Minneapolis, U.S. A windmill capable of giving 10 h.p., with a fifteen mile breeze, will be fixed on the tower, and connected to a dynamo, which will charge accumulators when the wind blows above a certain rate. A recording wind-pressure gauge, and a recording voltmeter will be provided to show at any time what has been put into the batteries, and a recording ampere-meter will be connected in the circuit to show what has been taken out. The plan as described is quite feasible, and its fulfilment is watched for with a good deal of interest at the locality that their frigid nor'-westers may be turned to some account towards diminishing instead of increasing the gas and coal bills. It may be mentioned that Prof. Blythe, of Glasgow, has successfully used wind power for driving dynamos to charge batteries, as also have the French authorities.

Fires from Electric Wires.—There have been quite a large number of cases of fire caused by electric light wires reported from America, the Lotus Club and the offices of the *American Magazine* both having a near escape. Mr. Heaphy, of the Phœnix Fire Office, has insisted on a much higher class of installation work in this country, and to the stringent precautions generally adopted here we must give credit for our immunity from these accidents. The same comparative slovenliness that characterises the running of American street electric light cables, railway tracks, and motor car cables, will no doubt lead to similar workmanship being employed interiorly in establishments where a slight accident can cause a great deal of damage. With all the advantages the Americans can claim, of quick workmanship, of "rushing," and "booming," the advantage may be bought very much too dearly if it leads, in a comparatively large percentage of cases, to liability to fires, and we should advise those in superintendence to insist on the most careful precautions against fire risks in their country, such as are now happily quite the rule in England.

Vacuum in Lamps.—The proposal has several times been made to prepare incandescent lamps with a filament which will need no vacuum. Independently from the difficulty or impossibility of getting a filament which shall fulfil the requirements of such a lamp, some experiments of M. Cailletet go to show that the absence of the vacuum, if one may use such a phrase, is by no means desirable on the score of efficiency of the light. M. Cailletet has found, when he has experimented with heating of wires by the passage of electricity under different pressures, that the heating effect decreases as the pressure increases. A current that will melt a wire of a certain thickness under ordinary pressure will only raise it to a dull red heat when surrounded by a high pressure. This would point out the superiority of lamps with a high vacuum over those filled with a neutral fluid, or with air when furnished with an incombustible filament. American circles are agitated with a report of a new Russian filament, said to be taken up by Westinghouse, which will stand twice the ordinary degree of incandescence without failure. Granting that such a refractory substance were discoverable, and was perfectly incombustible, M. Cailletet's experiments still show the advantage of the vacuum.

The Aid of Photography.—Seeing that the profession of electrical engineering is a practical one, far more than a literary or theoretic, all those extraneous means of aiding or advancing the practical issues of the business should be resorted to by those working in its ranks. As an aid of this kind, photography has begun to take its place in workshops, as the type-writer in literary offices, and to an enterprising young engineer, the knowledge of its uses and practical acquaintance with the methods of photography would be much better worth acquiring, as a rule, than other side branches of learning often taken up, shorthand for instance. Many large engineering works now keep their own photographic apparatus for use in sending descriptions, cataloguing, obtaining orders, or keeping particulars of special manufactures, and for anyone with a little spare time at his disposal it is both a pleasant and interesting occupation. Messrs. Lancaster, of Birmingham, are pioneers in cheap sets of photographic apparatus. Mr. Mayfield, late manager to Mawson and Swan, of Newcastle, gives attention to this branch as much as to electrical accessories. The Stereoscopic Company supply sets, and give instruction free to purchasers, and there are some admirable classes at the Polytechnic, Regent-street.

Overhead Wires in New York.—Not a little excitement has been caused in New York by the finding of the verdict by the jury investigating the death of Meyer Streiffer, a lad who was killed on April 15 by a shock from an electric light wire. Dr. Otto A. Moses gave evidence as to danger of high-tension currents, and stigmatised overhead wires as "a perpetual menace to human health, and a constant danger to human life. In Europe," he said, the overhead system would not be tolerated one instant." In a case of general breakage at a fire, Dr. Moses said there would be much danger. After an hour and a half's deliberation, the jury found that the death was due to the neglect of the United States Illuminating Company in not removing the loose wire, which was shown to have been hanging there for more than four weeks, thereby endangering the life of the public. The *New York World* organised a commission, consisting of an electrician, a photographer, and a reporter, to investigate the state of the overhead wires, and publishes many columns reporting upon the same, calling attention to the fact that, bad as it has been believed, it was nothing to the real state of the case, wires of all kind being mixed up indiscriminately, with promise of utmost danger in case of fire or accident, and concludes that "the wires will have to be put underground, or else many of the public will."

The Electric Light in Another Newspaper Office. There is, according to the *New York Electrical Review*, a very complete electric light plant in the new building of the *Post-Dispatch*, St. Louis. The dynamo is of the Edison

standard type. The capacity of the dynamo machine is 300 16-c.p. lamps, while the feeders and mains of the wiring system are proportioned for 600 16-c.p. lamps, which provides amply for the anticipated increase to 500 lamps of 16-c.p., or 400 lamps of 20-c.p. Since the dynamo is expected to give almost continuous service, the belts are so arranged that power may be had from either the Corliss or high-speed engine. The dynamo is also provided with a substantial brick and cement foundation surmounted by the wooden base frame necessary for insulation. On this wooden frame the side rails are securely bolted, the dynamo being held in position by its own weight in connection with the groves into which the slide rails fit to keep pulleys in line. The net weight of the dynamo is 2,880lb. The floor space occupied 66 by 50in.; the height above base of frame 4ft. The diameter of pulley, 12in.; revolution of armature per minute, 1,400. The 25 h.p. required to drive armature when under full load is transmitted by a light double endless Schultz belt. On the side wall, in position most convenient for the engineer, are found the regulator, the pressure indicator, the ampere-meter and the ground detector.

Lighting in America.—The following are some of the numerous items of new plants and extensions in America :—San Francisco is to have another large station, with a capacity of 1,000 arcs, and a goodly number of incandescents; in New Jersey the Edison Company have a contract for a central station of 2,500 lights at Sea Isle City; Sing-Sing, New York, is to have a large central plant; Hagerstown, Md., has 100 arcs and 1,200 incandescents; Knoxville, Tenn.; Robertsville, Conn.; Santa Ana, California, are lighted; Greenville, South Carolina, is to have 60 arcs and 400 incandescents. Under the United Company many central stations are being installed. Among others may be mentioned Freehold, N.J.; Jackson, Ohio; Greenville, Miss.; Charlottesville, Va.; Laredo, Tex.; Oswego, N.Y.; Cooperstown, N.Y.; Fulton, N.Y.; Massilon, Ohio; Chetopa, Kansas. We may mention, also, in the way of isolated plants, the Averne Hotel, at Rockaway Beach, to have a 400-light plant; Omaha and Grant Smelting and Refining Company, Omaha, Neb.; Marshall Saw Mills, Marshall, Cal.; Tivoli Opera House, San Francisco, Cal.; San Francisco Cordage Factory; Los Angeles College, Los Angeles, Cal.; Puget Lumber Company's Mill, Port Ludlow, Washington Territory. New York City has asked for tenders for lighting the city streets with some 400 arc lights. These are a few out of numberless items with which the American papers teem. Matters seem to be pretty brisk with electric lighting over there.

Eccentricities of Lightning.—The following letter appeared in the *Times* of May 26 :—"Sir,—The case mentioned in your impression of to-day of three persons sitting together, the two outer ones being killed by a stroke of lightning while the middle one escaped, is known to electricians. Arago (*Annuaires* for 1838) and others have recorded many examples. On the 2nd of August, 1785, lightning struck a stable at Rambouillet, where 32 horses were ranged in a line, side by side; the two outer ones only were killed. On the 22nd of August, 1808, a house at Knonau in Switzerland was struck. Five children were sitting on a bench in a room on the ground floor. Of these the first and last were killed on the spot, while the others experienced only a violent shock. In 1801 lightning fell on a windmill near Chartres, and set it on fire. The miller was approaching the mill between a horse and a mule, both laden with corn; the two animals were killed on the spot, while the miller escaped with a severe shock. In attempting to explain such facts, Arago instances the case of a bar of metal struck by lightning, which was apparently not much damaged, except at the spots where it made its entrance and its exit, so that in the above cases the intermediate bodies simply transmitted the charge. Many cases are cited to show that human beings resist the effects of lightning more powerfully than the lower animals. It is difficult to generalise on such cases as the above, however numerous they may be, seeing that we sometimes meet with exceptional cases. The following was related to a nephew of mine, while vicar of Denchworth, near Wantage. On the 9th of June, 1832, a woman, Martha Warman, was walking from Wantage in company with two men, she occupying the middle place, when about 1.30p.m they were struck by lightning and fell to the ground. The men soon regained their feet, but the woman was dead; her face, body, and clothes were cut and torn, her stockings set on fire, and her boots much rent. But seeing the curious way in which lightning picks out bits of metal, it must be noted that she had been carrying an umbrella, she wore steel in her stays, and had wire in her bonnet, which was fused and twisted. A cross by the wayside still marks the spot.—I am, &c., C. Tomlinson, F.R.S. Highgate, N., May 24."

South Kensington.—The official report of General Festing, R.E., upon the electric lighting at South Kensington Museum showed good things for the electric light. General Festing stated that the cost under the new lighting last year was £1,224; the cost of the same lighting with gas would be £2,845—a saving of £1,621 in favour of electric light. These figures seem to need some comment, as it is hardly likely that if it were quite clear that a saving of more than half were effected, and that the same could be expected from every public institution, so few public galleries would have been lighted. There are galleries and galleries, and at those where the gas lighting itself might be considerably reduced with a different disposition of gas jets, electricity, of course, has by far the better field before it. In galleries centrally lighted, where the disposition of the gas jets has been carefully attended to, and the greatest possible effect from gas obtained, it is well known among electrical engineers that it is not always possible to prove an advantage on the score of cost, and it is generally upon the distinct benefit from absence of heat and of dirt that the electric light has been adopted. But this favourable disposition of gas is not always present. In many galleries there are long lines of flaring gas-jets down each side of the room, sometimes containing many hundreds of burners, placed high, to be rid of fumes or scorching, and therefore, seeing that light varies as the square of the distance, considerably extravagant. It is these places where we can best see the way to advocate the electric light on the score of cheapness, as well as of cleanliness. One gallery in Bond-street, hitherto lighted with double rows of gas-pipes, containing 120 burners, is now lighted with 12 or 14 incandescent lamps of 50 c.p. quite as effectively, if not more so, than with the gas. The additional advantage is also found of immediate light being obtainable by the motion of a switch handle, instead of the troublous method of lighting a taper and proceeding gradually around to light the rows of burners while the gas is escaping. We commend the serious consideration of the South Kensington report to the principals of the National and other galleries.

ARTISTIC FITTINGS.

II.—FARADAY AND SON.

At the time of the first development of the incandescent electric lighting in this country after the historical lectures of Mr. J. W. Swan, and the exhibitions of lighting at the Paris and Crystal Palace Exhibitions, apart from the scientific interest of the invention, not a little of the interest that the beauty of the lamps called forth was due to th attention that Messrs. Faraday and Son gave to the gracefu appearance of the special fittings there used. Having a larg connection among public institutions and West End privat individuals, this firm were in a position to gauge th necessities of the occasion, and enterprising enough to throw themselves *con amore* into the breach now provided for t introduction of suitable fittings for the new light. In ma places at first nothing seemed to be thought of th

FIG. 1.

FIG. 2.

FIG. 5.

FIG. 3.

FIG. 4.

FIG. 6.

the adaptation of existing gas and oil fittings to the wires of the incandescent lamp, but it was soon recognised that the character of the light was essentially different from that of gas, that appearance practically was all that need be considered, the lamps being adaptable to any situation and position. A much lighter form of fitting then became the desideratum, and those light elegant floral designs originated by Faraday's were speedily adopted. The now almost universal tulip or lily glass,

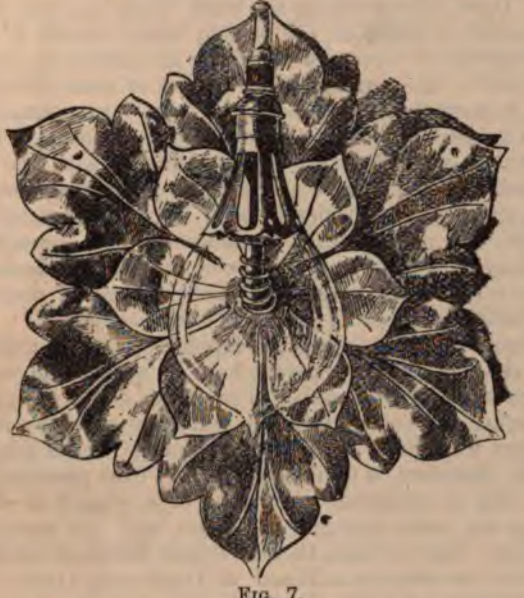


FIG. 7.

like the petals of a delicate flower, blown in blue or straw opal glass, was originated in this firm's show-rooms, and was the outcome of mutual deliberations of Mr. Alfred Waterhouse, F.R.I.B.A., the well-known architect of the

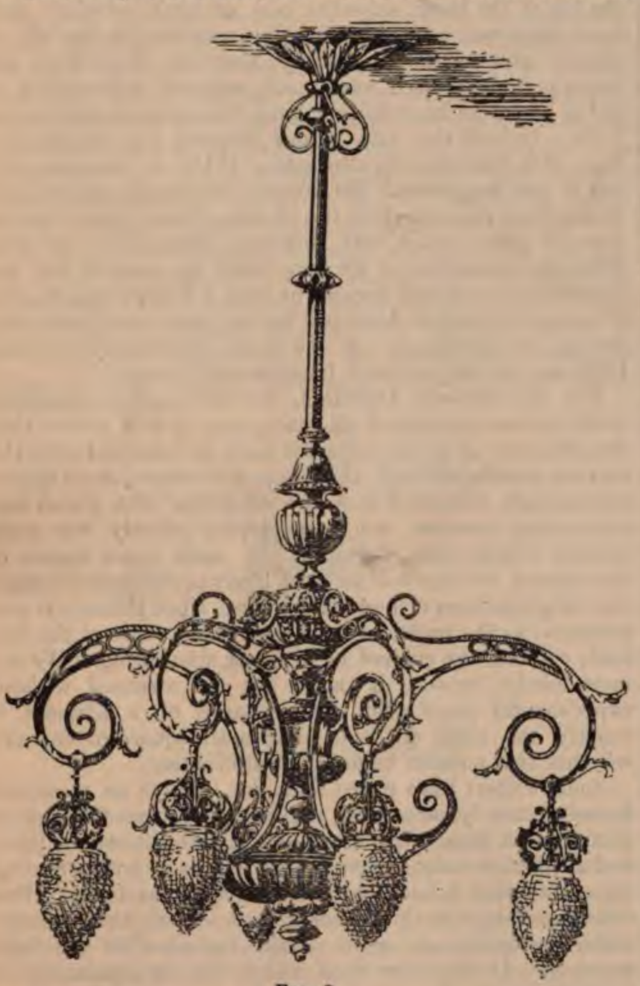


FIG. 8

Law Courts, &c., and Mr. Harold Faraday, and was rapidly adopted wherever the incandescent lamps came in use. When Mr. J. W. Swan gave the first lecture before the Royal Institution and at the *conversazione* at the Royal Academy, the fittings were designed specially by this firm,

FIG. 9.

FIG. 10.

and also for the before-mentioned Paris Exhibition, where the memorable display of the first patented Swan lamps was brought before the world, and at the exhibition of

Messrs. Siemens and Swan at the Crystal Palace. Simple and elegant, or rich and elaborate, the light lends itself easily to either treatment, and we give illustrations this week of some of the more noticeable and novel designs of artistic fittings designed and made by Faraday and Son. The speciality of the firm seems to be that of brasswork in all its forms—polished, and gilt or silvered, in airy and elegant shapes, as distinguished from the more ponderous of some other forms of fittings. Not a little of this effect is due to the special holder, named the "Sydenham Holder," of which we give an illustration (Fig. 1). It is made in pierced brasswork, of a shape that fits and carries out the lines of the lamp globe, and enables the lamp itself—ground glass or plain—to be fitted in beauty unadorned in many cases most effectively, a result hardly possible with the old forms of outside wire springs, or large metal cases. The fittings, Figs. 2 and 3, show this; one is a simple little standard for a piano, to be connected with a flexible cord to the wall plug, and moved about on the piano. The arm is jointed, the joint being a concentric contact of two brass spheres, is not liable to short-circuit. Fig. 3 is a very useful little pendant with a white porcelain ribbed reflector, behind which the lamp is hung for use in front of pictures, or in shop windows, or any position in which the light is required to be guarded from the eyes and thrown in front. The centre of gravity is shifted by means of the wire arm, so as to cast the reflector forward as shown.

A very pretty design is shown in Figs. 4 and 5, which Messrs. Faraday have made their own. Filigree work of hand hammered flat brass in little curls surround the opal glass inside which the lamp is fixed. It is suspended on flexible cord, which is often variously adorned with beads, or rings, or knobs of Eastern wood, or turned in brass. Sometimes these pendants are oxidised in antique patina bronze, to increase the Oriental effect. The parachute pendant, Fig. 6, is a useful and very ornamental little fitting; a silk shade with fringe shades the lamp, and the flexible attachment is coiled on a spring drum, which allows it to be raised or lowered by slight pull of the cord in the manner of the patent blinds. Messrs. Faraday make several patterns of ornamental counterweight pendants with cords and pulleys. An adjustable pendant invented by Sir David Salomons, and named by him the "Perfect" pendant—a great favourite in installations, being universally adjustable —has three cords of attachment, which run over separate pulleys, so that, besides motion up and down, it can be tilted, and will remain pointing in any direction. This fitting is very useful both for ladies' dressing-rooms (where very particular and artistic operations must be performed) and also for drawing offices, as it can be raised or lowered and shaded from the eyes. The fittings illustrated by Figs. 7 and 8, the floral and celandine brackets are of hammered copper, or copper and brass mixed, of a leafage or floral design, and are very effective in certain positions, the warmth of the reflection of the polished copper being harmonious and soft. A handsome electrolier is illustrated at Fig. 9, selected out of several various and equally artistic designs suitable for use in large drawing-rooms or similar positions. It is in wrought and turned brass work, chased by hand, leafage in decorated *repousée* work, with engraved arms, and with filigree brass work crowns to fit the cut-glass pine-shaped shades. These electroliers are also very effective when finished, as is often the case, in antique oxidised silver, and with crimson suspending cords. Of standards of all kinds for offices, writing tables, drawing-rooms, and bedrooms, there is a large variety. We illustrate one a little out of the common, Fig. 10. The stand is a sculptured mask, with Renaissance decoration, and bears a silk shade with lace fringe, and is very suitable for a lady's boudoir or drawing-room.

THE EFFICIENCY OF INCANDESCENT LAMPS WITH DIRECT AND ALTERNATING CURRENTS.*

BY W. E. AYRTON AND JOHN PERRY.

It is now well understood that in order to economically distribute power by means of electricity, it is necessary to employ a high potential difference, or P.D., between the mains and a small current flowing through them; while considerations of safety require that the P.D. between the leads in the houses shall not exceed 100 or 200 volts. Hence, some system of converting a large P.D. and a small current into a small P.D. and a large current has to be employed, and the four systems of conversion that have hitherto been devised consist in the employment of—(1) motor-dynamos, (2) accumulators, (3) alternating current transformers, (4) direct current transformers.

Of these four methods, the third is the one that is most extensively utilised at the present time; indeed, it is the only system of conversion that is at all extensively used, at any rate in this country. But in view of some direct current system of conversion coming also into common use, there arises a question of considerable importance to the consumer—viz.: Is more light obtained with the same expenditure of power with direct or alternating currents? And, apart from considerations of the electric distribution of power on a large scale, the answer to this question is of importance in supplying one factor towards the decision as to the relative advantages and disadvantages of direct and alternating currents for detached installations.

Where the electric energy supplied to a consumer has been charged by meter, people have, as a rule, been content to measure only the number of coulombs supplied, ignoring altogether any variation in the volts; but as electricity *per se*, apart from the P.D., is of no commercial value whatever —and, therefore, is unlike water apart from pressure—it is clear that in estimating the value of a supply of electric energy we must measure the watts, and not merely the current. The problem, therefore, that we have attempted to solve is whether a Board of Trade unit (1,000 watt-hours) is more valuable for lighting by incandescent lamps when the current is direct or when the current is alternating.

For a complete solution of the problem we must ascertain not merely the "efficiency of the lamp" or number of candles per watt with the two systems of supply, but also the life of the lamp, since the cost of lamp renewals may be as important a question for the consumer as the bill for electric power. Unfortunately, however, there does not exist, as far as we are aware, any accurate information as to the life of an incandescent lamp with various alternating P.Ds. Indeed, the data at our disposal for the life of a lamp with various non-alternating P.Ds. is most meagre; and if any member of the society can supply us with any information regarding the life of some fixed type of incandescent lamp, either with different direct P.Ds. or with different alternating P.Ds., we shall be grateful for the information, as it will furnish us with a further opportunity of using the method described in our paper read before this society for deciding "On the most Economical Potential Difference to Employ with Incandescent Lamps."*

For the present, therefore, we shall confine ourselves solely to the question of efficiency, and, as it is known that the efficiency of an incandescent lamp is increased with the current passing through the lamp, it is clear that to obtain an accurate comparison of the efficiency with direct and alternating currents, we must employ exactly the same current in both cases, or rather the same mean square of the current, for this will be most likely to develope the same rate of production of heat in the lamp, since this rate is proportional to the resistance into the mean square of the current, whether the current be direct or alternating. We say most likely, because it must not be assumed without experimental proof that the resistance of a filament is exactly the same for the same mean square of current, whether that current be direct or alternating.

Some writers have stated that the current, as measured by an electro-dynamometer, required to be sent through an incandescent lamp, when emitting a definite amount of light, had a different value, when the current was an alternating one, from what it had when the current was direct. This difference might be due either to a defect in the dynamometer measurement, or to some variation in the light standard. If the wire with which the dynamometer is wound be thick, then the current density may be far from uniform when the current is alternating; and on this account, as observed by Captain Cardew some years ago, a

* Read at the Physical Society of London.

*Phil. Mag., April, 1885.

TABLE I.

—	$\sqrt{A^2}$	$\sqrt{V^2}$	Watts.	Green. a	Green. b	Green. Candles.	Green. Watts per Candle.	Red. a	Red. b	Red. Candles.	Red. Watts per Candle.
Ferranti	1·34	50	67	107·7	22·3	23·33	2·872	106·5	23·5	20·52	3·265
Gramme	1·34	50	67	107·8	22·2	23·52	2·848	106·4	23·6	20·34	3·295
Ferranti	1 34	50	67	107·9	22·1	23·74	2·823	106	24	19·51	3·435
Gramme	1·34	50	67	108	22	24·11	2·779	105·9	24·1	19·32	3·469

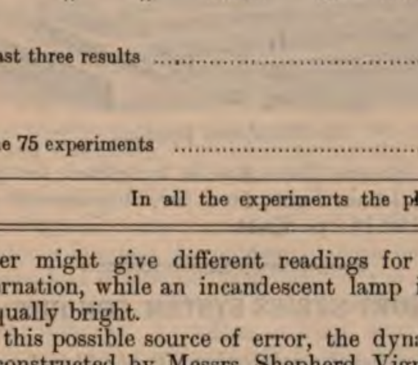
TABLE II.—MEAN VALUES OF

Lamp.	Number of Experiments made.	$\sqrt{A^2}$	$\sqrt{V^2}$	Watts per Candle. White Light.	Time of an Alternation in seconds.
50-volt M-shaped filament	20	...... 1·25	...... 50·5	Gramme. 3·053 ...... Ferranti. 3·033	$\frac{1}{453}$
				Green Light. Gramme. Ferranti. Red Light. Gramme. Ferranti.	
50-volt horseshoe-shaped filament	19	...... 1·30	 50	2·597 ... 2·534 ... 3·100 ... 3·100	$\frac{1}{453}$
,, ,, ,, ,, ...	20	...... 1·34	 50	2·935 ... 2·966 ... 3·254 ... 3·164	$\frac{1}{167}$
,, ,, ,, ,, ...	16	...... 1·35	 50	2·900 ... 3·073 ... 3·504 ... 3·477	
Mean of the last three results				2·811 ... 2·857 ... 3·286 ... 3·247	
Mean of all the 75 experiments				Gramme. 3 0490 ...... Ferranti. 3 0497	

In all the experiments the plane of the filament was perpendicular to the screen.

dynamometer might give different readings for different rates of alternation, while an incandescent lamp in circuit remained equally bright.

To avoid this possible source of error, the dynamometer which was constructed by Messrs. Shepherd, Vignoles, and Wheatley (the three of the students of the Central Institution who carried out the investigation) was wound with much finer wire than would usually be employed in the construction of a dynamometer not required to read currents much below one ampere. The dynamometer was for that reason unnecessarily sensitive, and it required a fairly strong spring to control the motion of the suspended coil. This led to an unnecessary waste of energy in the dynamometer, but that was of no consequence in this investigation, as our object was to measure the mean square of the current most accurately, and not to satisfy the condition, which is of considerable importance in the design of commercial measuring instruments, of wasting as little energy as possible in the instruments.



To the suspended coil of the dynamometer was attached a mirror, and the values of the deflection of the spot of light were determined by direct comparison with the simultaneous readings of an accurately calibrated spring ammeter when various direct currents were sent through the circuit. The sensibility was such that a deflection of 400 scale divisions was produced on a scale 68·88 inches away for a current of 2·53 amperes, which corresponds with a deflection of 140 scale divisions for 1·5 amperes, which was about the usual current passing through the dynamometer in the actual lamp experiments. The values of the current could, therefore, be accurately measured by the dynamometer, which is indicated by D in the figure, and then, by knowing what fraction of the current passing through the dynamometer, D, passed through the non-inductive voltmeter, V, the current passing through the lamp is known.

Any error that might have arisen from a variation of the light standard was eliminated by taking successive readings with a direct current produced by a Gramme dynamo, G, and with an alternating current produced by a Ferranti dynamo, F, the switches, S and s, being turned to 1, 1 in the first case, and to 2, 2 in the second. The Gramme dynamo was also used to excite the field-magnets of the Ferranti, a suitable current being obtained by a proper adjustment of the resistance, p. By means of the resistances, q and t, the direct and alternating currents passing through the incandescent lamp, L, could be respectively varied; and it was found that if the resistances were so adjusted that the reading on the dynamometer, D, was the same in both cases, so also was the reading on the non-inductive voltmeter, V.

It is known that when power is supplied by means of an alternating current to a circuit of resistance, r, ohms and coefficient of self-induction, l, secohms that

$$\frac{\text{Number of true watts}}{\text{Number of measured watts}} = \frac{r\,\tau}{\sqrt{l^2\,\pi^2 + r^2\,\tau^2}},$$

where the measured watts were obtained by multiplying $\sqrt{A^2}$, the square root of the mean square of the amperes as measured by the dynamometer, by $\sqrt{V^2}$, the square root of the mean square of the volts, as measured by the non-inductive voltmeter, and where τ is the time between one alternation and the next, or half the periodic time. Therefore the

$$\text{Number of true watts} = \frac{r\,\tau\,\sqrt{A^2\,V^2}}{\sqrt{l^2\,\pi^2 + r^2\,\tau^2}},$$

where in our case r and l are the resistance and co-efficient of self-induction of the carbon filament of the lamp. In the first set of experiments a lamp with a looped filament was employed, but the experiments seemed to indicate that the value of l was not quite small enough to make the term $l^2\pi^2$ absolutely negligible, or else that there was some slight mutual induction between the dynamometer coils and a small brass vessel containing oil, in which moved a damp-

ing vane, attached to the moving coil. The results were therefore discarded, and this vessel was removed and replaced with one made of non-conducting material, and all metal near the dynamometer was, as far as possible, removed. The lamps subsequently employed were, first, one with an M-shaped filament, and another with a simple horseshoe-shaped filament, each possessing little self-induction.

The light was measured by comparison with a standard candle, the two being placed 130 centimetres apart on the photometer, P, and a screen, composed of two pieces of paraffin wax, W, with silvered paper between them, was adjusted until the two pieces of wax appeared equally bright, the comparison being first made when the screen was looked at through ruby-red glass, and then through signal-green glass.

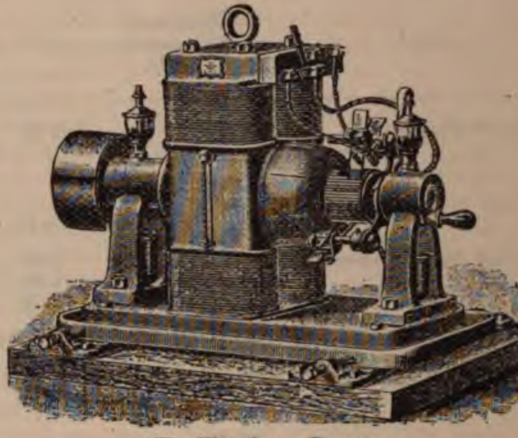
The following is a sample of the results obtained, a and b being the distances respectively of the screen from the incandescent lamp, and from the standard candle :—

It will be observed that in the set of four successive observations given in Table I. for green light, the candle-power of the lamp appears to be steadily increasing, a result probably due to the brightness of the candle slowly diminishing; but although this would make the absolute determination of the efficiency of the incandescent lamp inexact, it introduces no error in the determination of the relative efficiencies of the lamp with direct and alternating currents, since every observation with the direct current was immediately followed by one with alternating current, so that the means of all the corresponding direct current measurements may be safely compared with the means of all the alternating current measurements. Similarly, it is unimportant whether the standard candle used on one day was slightly more or less bright than the standard candle used on the following day. Further, since for any two successive observations with the same coloured light with direct and with alternating current, the screen was at practically the same distance from the lamp, the fact that the rays of light coming from the lamp made a somewhat different angle with the surface of the paraffin wax from the angle made by the rays coming from the candle introduced no error in this investigation of *comparative* efficiencies, although it might very likely do so in the *absolute* determination of the efficiency of an incandescent lamp. In fact, the simple device of successively taking observations with direct and with alternating currents throughout the whole investigation, removed most of the objections that usually may be made against photometic determinations carried out with a candle as the standard of light.

Disregarding the experiments made with the lamp with the looped filament for the reason given above, Table II. gives the summary of the results obtained; and the conclusion to be drawn from them is that although the watts per candle for green light are not quite the same for direct and for alternating currents, and although the watts per candle for red lights are also not exactly the same for direct and alternating, still the difference between the results is so small that it may be put down to experimental errors, and this, combined with the fact the mean of all the 75 experiments gives practically the same number of watts per candle for both direct and alternating currents leads to the practical certainty that *the efficiency of an incandescent lamp is the same for both direct and alternating currents.*

A SMALL SELF-REGULATING DYNAMO.

Our illustration represents the improved self-regulating dynamo of small size built by the Waterhouse Electric and Manufacturing Co., of Hartford, Conn. It will be remembered, says the *Electrical World*, that the regulation of these machines is effected without shifting the brushes. It will be noticed that there are three brushes on the commutator —the two main brushes and an auxiliary brush. The current from the auxiliary brush passes to the lamp line outside of the field magnets, and the current from the upper main brush passes around the field magnets and then joins the current from the auxiliary brush, and the sum of the two is the current passing to the lamps. At the instant of cutting out lights, the current from the main brush decreases while the current passing from the armature by way of the auxiliary brush increases; but this increase is in like proportion to the decrease of the main current, and the current on the lamp line, which is the sum of the two currents, remains normal. This balance, which, it is true, seems difficult to conceive in practice, is yet vouched for to take place in the machine, so that its operation is perfectly automatic. The new machine has been further improved by the addition of a new brush-holder, and the commutator is composed of drop-forged copper segments. The groove near the rim of the pan prevents any oil from saturating the floor, and the slides, with adjustable bolts, insure a tight



The Waterhouse Dynamo.

belt. The dynamo illustrated is furnished for plants of 3, 5, 10 and 12 arc lights, and for incandescent plants of 30, 50 and 100 16 c.p. lights.

SHORT SERIES SYSTEM CONDUIT.

We have recently referred to Prof. Short's system of using electricity for traction purposes. The accompanying figure shows a section of the conduit he uses, but, fortunately for the electrical engineering industry in America, in the

Prof. Short's Conduit.—Section.

smaller towns our cousins seem to have no great objection to the use of overhead conductors, which are less expensive and less troublesome to maintain.

MAGNETIC QUALITIES OF NICKEL.*

By J. A. Ewing, F.R.S., Professor of Engineering, University College, Dundee, and G. C. Cowan.

The experiments described in the paper were made with the view of extending to nickel the same lines of inquiry as had been pursued by one of the authors in regard to iron (Phil. *Trans.*, 1885, p. 523). Cyclic processes of magnetisation were studied, in which a magnetising force of about 100 c.g.s. units was applied, removed, reversed, again removed, and re-applied, for the purpose of determining the form of the magnetisation curve, the magnetic susceptibility, the ratio of residual to induced magnetism, and the energy dissipated in consequence of hysteresis in the relation of magnetic induction to magnetising force. Curves are given to show the character of such cycles for nickel wire in three conditions : the original hard-drawn

* Abstract of a paper read before the Royal Society, May 17.

state, annealed, and hardened by stretching after being annealed. The effects of stress have also been examined (1) by loading and unloading magnetised nickel wire with weights which produced cyclic variations of longitudinal pull, and (2) by magnetising while the wire was subjected to a steady pull of greater or less amount. The results confirm and extend Sir William Thomson's observation that longitudinal pull diminishes magnetism in nickel. This diminution is surprisingly great. It occurs with respect to the induced magnetism under both large and small magnetic forces, and also with respect to residual magnetism. The effects of stress are much less complex than in iron, and cyclic variations of stress are attended by much less hysteresis. Curves are given to show the induced and residual magnetism produced by various magnetic forces when the metal was maintained in one or other of certain assigned states of stress; also the variations of induced and residual magnetism which were caused by loading and unloading without alteration of the magnetic field. Values of the initial magnetic susceptibility, for very feeble magnetising forces, are stated, and are compared with the values determined by Lord Rayleigh for iron, and the relation of the initial susceptibility to the stress present is investigated. The paper consists mainly of diagrams, in which the results are graphically exhibited by means of curves.

LITERATURE.

A Pocket-Book of Electrical Rules and Tables for the use of Electricians and Engineers. By JOHN MUNRO, C.E., and ANDREW JAMIESON, M.I.C.E., F.R.S.E. Fifth Edition Revised. [London: Charles Griffin and Co.]

When a book of this kind has reached a fifth edition in less than four years, and when the preface to each edition refers to corrections and additions, the interest of the critic is apt to flag, and his work becomes a mere monotonous repetition of the fact that "another edition has been issued." There is one use of such a work as this which is too often overlooked, that if generally adopted, as this evidently is, it consolidates our notation and nomenclature, and tends to stop the vagaries of ambitious authors from framing a notation for themselves. The authors of the pocket-book, however, should be careful to accept and define terms which are practically adopted — such, for example, as "impedance," and other terms suggested by Mr. Oliver Heaviside, and generally used by authors. Magnetic permeability, again, does not find a place, or we have failed to find it. The authors who excel in compiling this kind of work have not only the ability to decide what is useful from among the common property of engineers, but also the prescience to foresee what is at the moment only in the air, yet in the near future will be accepted by the profession. The first editions are not expected to be complete, but as time goes on, and new editions are issued, the corrections and additions should become microscopically small. It is impossible to enter into detailed criticisms. We know the book, and have used it constantly since the first edition appeared, and always with satisfaction. Still, there are some alterations or emendations that in our opinion might be made—principally, however, in arrangement. Thus, p. 6, last line but five—

Work. $W = FL =$ (eq. 3) L^2MT^{-2}; we prefer

Work. $W = FL =$ (eq. 3) $L = L^2MT^{-2}$; or,

Work. $W = FL = L^2MT^{-2} =$ (eq. 3) L.

Take, again, the tables relating to measures of length, p. 24. The equivalents for 1 and 100 are useful; but equivalents for, say, 1, 2, 3, 4, 5 and 10, would be very much more useful. Further, the money equivalents, p. 32, ought to be extended. Estimates are not made for France only, but for every civilised nation under the sun; but while 90 per cent. of business men know something of French money, a lesser number know about Spanish, Portuguese, Italian, Brazilian, Chinese, Japanese, &c. Jumping to near the end, p. 422, we object to the attempt to Anglicise "galvanoplasty." Such alterations as we have suggested, and similar ones, would further improve a work upon which the authors have evidently spared no pains to make as comprehensive and useful as possible, and which, in fact, is a necessity to every man connected with electrical engineering.

CORRESPONDENCE.

ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I hope you will allow me to state a few words in reply to the letter appearing in your last issue signed "F. C. Allsop." What he states about the trials of Mr. Reckenzaun is quite true; but the lines upon which I am working are different. In the article by J. L. Huber it will be seen that practice has dictated the use of a double armature. If Mr. Allsop will think again, he will perceive the reason of both armatures being perfectly cool—because the strain is divided. Had the full strain been placed upon one, it would no doubt have become very much heated.

One of the main points I aim at is to keep the armatures as cool as possible, because of the fact that when a conductor becomes heated its resistance increases. Hence the advantage of starting upon each journey with a cold armature.

Another feature, and a very important one too, is the fact that a tramcar in ordinary traffic *must keep its time, no matter the number of stoppages.* Two armatures enable this to be done far better than one at any time a good speed is required with a heavy load. As to cost, the car in question has never exceeded *five farthings per mile run for coke burned under the boiler*, and this consumption will be reduced to a halfpenny as soon as the cars can be got to work. The comparison is considerable between the seven ton electric locomotives at Stratford and their load and the self-contained cars which I propose, which will not weigh a pound over four-and-a-half tons. There will be only sixty cells, weighing, with their total contents, 50lb. per cell.

I am decidedly of opinion that electric traction, like everything else, will stand or fall by its commercial value. If a farthing per mile can be saved over horse-haulage, depend upon it it will be only a matter of time to displace the horse for tramcar haulage.

The report referred to does serve a purpose, and that is, the amount of energy used to do a certain amount of work, the present car complete weighing five tons. The repeated trials with accumulator cars in my experience has had a good effect upon the public mind, and tramway companies, like sensible people, will see any system of electric haulage thoroughly proved first upon all points before they will adopt it. One thing is certain, no half-hearted men need touch the subject of electric traction, and those that have the pluck and energy to carry it out to a successful issue should have their just reward.—Yours, &c.,

Brixton, S.W., May 30th, 1888. A. J. JARMAN.

TAVENER COULOMB METER.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—As you inserted in last week's *Electrical Engineer* a description of an electric meter by Prof. Elihu Thomson, which is identically the same in principle as one patented by me in 1884, and, as a correspondent has called your attention to the matter, I feel I should not leave the indication of my claim entirely to others. I may add to what your correspondent has already stated that had there been no patent to fix the date of my prior claim, I could have brought ample testimony that I had been some time prior to 1884 experimenting on the heating effects of the current, with the object of constructing an electric meter, as it appeared to offer the only means of making a generally useful instrument applicable both to alternating as well as to direct currents, and which resulted in the adaptation of the tube with bulbs to that purpose as the only solution of the difficulties of using the heating effects of the current in the way I have with a variable surrounding atmospheric temperature and pressure.—Yours, &c.,

J. TAVENER.

South View, Basingstoke, Hants, May 29, 1888.

THE

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S

THOMSON v. THOMPSON.

"Unfortunately I arrived just at the conclusion of Sir William Thomson's address," said Prof. Sylvanus P., "but I have just one question to ask, and that is, When will Sir William supply us with electrical measuring instruments at half-a-crown each, as accurate for their purposes as are the cheap watches for keeping time?" The audience laughed, and many of them ridiculed the idea of Sir William Thomson's splendid instruments being obtainable for half-a-crown. This we may fairly say was not Prof. Sylvanus Thompson's idea. Had he cared to explain—unless indeed our interpretation of his meaning is wrong—he would have said that the world of pure science needs instruments of the greatest precision, and these Sir W. Thomson is supplying; but the world of applied science does not require instruments of such great precision, nor indeed can it use them if it has them; but it requires something cheap, handy, and fairly accurate—instruments that will survive a considerable amount of rough usage. Examples of the use of the two classes of instruments can be selected in any direction. The draper who measures so many yards of calico, troubles himself nothing at all about the accuracy of the standard yard. The ordinary surveyor with his chain troubles himself nothing about the accuracy of a base line for a trigonometrical survey. The object of the standard yard is not to measure calico, nor is the accurate base line wanted to obtain the area of the kitchen garden. The draper's measurement is perfectly satisfactory for all practical purposes, so is that of the ordinary surveyor. Just so, then, may less precise calculations be satisfactory for all practical purposes in electrical engineering work, and the workman will be satified to get a correct result within ·01 just as much as if it was correct to ·00001. Prof. Sylvanus Thompson took an example of cheapness and accuracy of measurement from the work of watchmakers, but he would be the last man to contend that the cheap American, Swiss, or English watches were sufficiently good timekeepers for standards in astronomical work. He would admit both classes of instruments had their uses, and we should be inclined to contend that his question was put to the wrong person. It is not to Sir William Thomson that the scientific world looks to produce instruments that are "about" right; they rather look to him for the accurate scientific weapons by means of which they can tell the "aboutness" of those instruments called for by Prof. Sylvanus Thompson. Messrs. Schuckert, Deprez, Ayrton, and Perry, Kapp and Crompton, Muirhead, Paterson and Cooper, Howard, Appleton, Burbey and Co., and such like designers and manufacturers are the people to whom we must look for these cheaper tools for the workman, and it may fairly be maintained that their part of the work has not been

badly done, or the period which has elapsed since the want was felt been unduly long before the cheapening commenced. It may well be said that the function of the standard yard is to measure other yards, so the function of Sir William Thomson's admirable series of instruments seems to be to measure, compare, or standardise other instruments rather than be placed themselves in the dynamo rooms for everyday use. Generally, and within certain limits, cost is directly proportional to accuracy, and, other things being the same, the cost of the instrument accurate to ·1 will be less than the cost of the instrument accurate to ·01. Thus, before Prof. S. P. Thompson can safely determine the price at which an instrument should be sold, he and others holding similar views must determine the point of accuracy to which these cheap instruments are expected to work. Something was said about accuracy to one per cent., and so far as the greater part of electrical engineering work is concerned, that percentage of error might not be inconvenient, but there are many cases in which it could not be allowed. Perhaps the accuracy that will be tolerated for practical purposes may be set down as ·001, and if what is said about the extreme accuracy to which electrical measurements can be carried, there ought to be little difficulty in getting the cheap working instruments to the accuracy we have mentioned.

CRITICISM ON THE ELECTRIC LIGHTING BILL.

It is a great pity that some of the writers upon this subject do not make themselves acquainted with the rudimentary principles of trade and finance. In the last number of the *Local Government Chronicle* is a short article on the Electric Lighting Bill, in which are the following remarks :—"The experience of the present generation in towns where the gas works or water works are owned by companies ought to be a warning for all time against the setting up of any similar monopolies. If the electric light had been as great a success as gas soon became after its introduction, we doubt whether the terms imposed by the Act of 1882 would have had much effect in deterring enterprise; and until some company can show a large margin of profits from its electric undertaking, we doubt whether the present Bill will have much effect in stimulating it."

The electric light industry has not asked for a monopoly—it does not want it; but it wants fair play and just that latitude and licence that is given to almost every other trade under the sun. Does our sapient contemporary think that a grocer or a tailor would do much in the way of business if he knew that before he had time to look round a second party could step in and say, "I'll take your business off your shoulders at my own price." Does a full-blossomed business drop into the hands of any man who opens a shop and sets up a sign? How many years elapse before the capital sunk in making a business is returned? The great cry of many engaged in electrical engineering is that they cannot influence sufficient capital for the work in hand or in sight. The capitalists say no business under the sun can succeed if handicapped with such provisions as that under discussion. They will not wait five or six years for a dividend while a company is being developed; they want a good return at once; and till there is some prospect of this and of a continuity of return great difficulty will be experienced in the matter of capital. Talk about monopoly! If there was the slightest chance of monopoly, capital would be plentiful; but confiscation is rather the term to be used, and the word frightens those who hold the purse strings. Generally, the consent of two parties is necessary to make a bargain. You cannot compulsorily purchase the farmer's cow because he has had it six months or six years. In fact, the case of the farmer, which has been so much discussed of late years, is somewhat analogous to that of the electric light company at the end of twenty-one years. He has agitated and has been granted compensation for "unexhausted improvements"; but under the old Bill the company neither got return nor compensation; and though we admit forty-two years is better for the undertakers, the principle is radically wrong. If the concern is to be taken over compulsorily at any time, it should only be by paying a fair and square compensation.

ENGINEERING ELECTRICAL.

Electrical work as heretofore carried out up to the last few years was little else than purely electrical. Now the case is widely different, and will become rapidly more so. An electrician who has not been through the mechanical engineering shops, and who undertakes a large installation comprising machinery and boilers, gearing and shafts, may sometimes involve himself in considerable difficulties through not sufficiently considering, or being able to consider, the engineering part of his plant. In the future, no doubt, electrical engineers will more and more be engineers quite as much as electricians, but at the present time there are a large number of electrical engineers who need further experience in the latter half of their business. It is often useless to expect these to give up a year or two of their time to be re-apprenticed to an engineering firm to obtain a through training by going through the shops. There are, however, several ways of meeting the question which it might be quite worth while to point out. Not the least efficacious of these methods, of course, will be to attend a course of mechanical engineering instruction where practical work in engineering is allowable, and where occasion is afforded for fixing, taking to pieces, and repairing steam engines, gas engines, and shafting. But it may be quite worth the while of some of our more advanced electrical engineers to obtain when they can a position in an avowedly engineering firm—many of such we could name—who do not lay themselves out to make electrical machinery, but who do make a speciality of engines and machinery connected therewith. A person with good electrical knowledge, and willing to help and learn, might there find both scope for what he does know and ample opportunity for furthering the development of what we have called his "engineering electrical." These firms

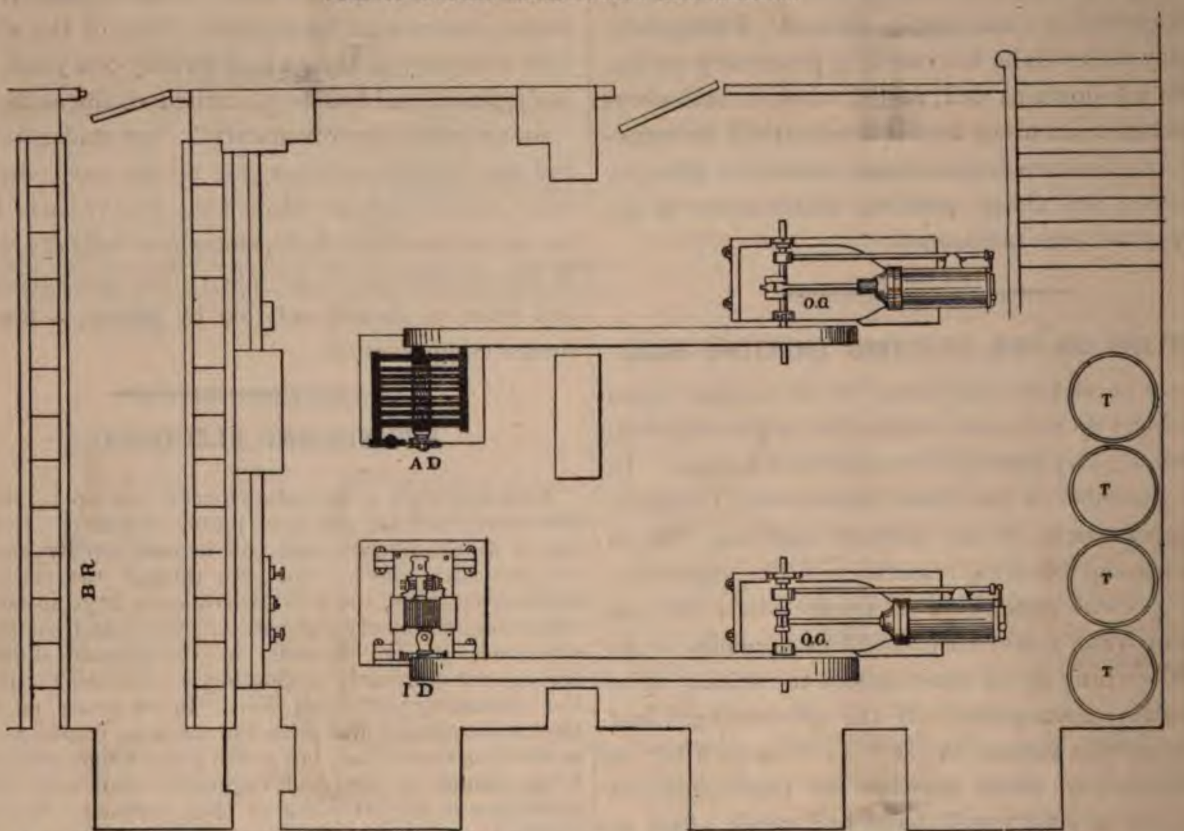
constantly work in conjunction with true electrical firms, and the experience thus gained would no doubt serve many who now labour somewhat under a disadvantage when the heavy part of their work has to be considered. As a third resource, we would have them not forget that our friends the mechanical engineers *are* our friends, and are ever ready and willing to help us in any difficulty with which they themselves are better able to grapple. Especially would that be the case when any pecuniary or contractor's advantage might be looked forward to. The electrical engineer should feel that he has at his back, as permanent consulting engineer, the whole of the best of the mechanical engineering trade, to whom he can go to in confidence in case of difficulty of arrangement in engineering skill—a partner to whom he should not hesitate to look to, who is ever ready to help, and whose help when taken will often obviate many faults, bring into use many labour-saving suggestions, and enable the resulting work to redound to the credit of both.

INSTALLATION AT PEARS' BY MESSRS. LAING, WHARTON, AND DOWN.

We herewith illustrate the dynamo and battery rooms of what is perhaps one of the prettiest of the London installations. It could hardly be expected that one of the greatest, if not the greatest, advertisers in the whole world would miss the opportunity offered by the electric light, and especially so as it combines profit with pleasure. The profit arises in that, all things considered, at the present moment "it doth give Pears' a cheap advertisement," and the pleasure from the fact that the working staff get a better light and better ventilation than would be the case using any other illuminant. It is beyond our province to enter into any detailed description of the architectural features of the building, but it is worth a special visit to Oxford-street to see the ante-room, and to view the pictures. The electric light plant consists of two of Crossley's "Otto" gas engines, one driving a Thomson-Houston machine for arc lighting, the other a Jones dynamo for charging a storage battery. The arc lamps are not much used in summer time, so that the work at this season of the year falls almost wholly upon the storage battery. Current is taken from it not only for the incandescent lamps, but also to actuate a small Immisch 4 h.p. motor, which works the lift. The fittings used are principally simple and neat office fittings, but an exception must be made to the bronze lamp used in the ante-room, which is fashioned after the manner of the old Roman hand-lamps, and looks extremely tasteful. It is perhaps hardly necessary to add that the grouping of the incandescent lamps in the ante-room is specially arranged to effectively light the exquisite marble statuary.

Imitation Roman Lamp.—Pears' Installation.

PLAN OF DYNAMO ROOM.—PEARS' INSTALLATION.

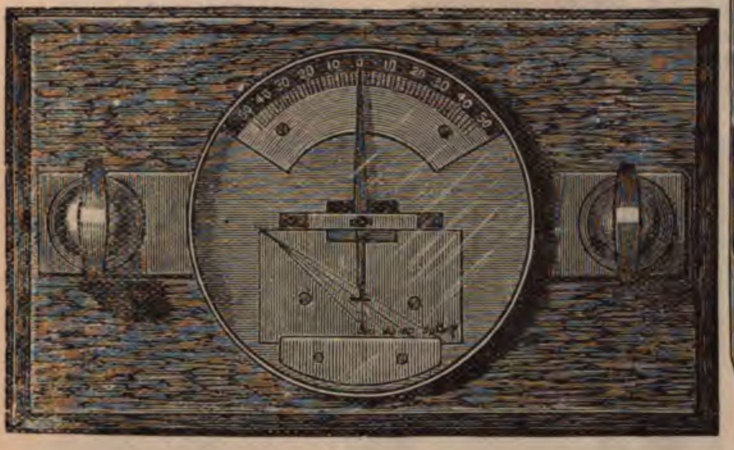


B R Battery Room. A D Arc Light Dynamo. I D Incandescent Light Dynamo. O G Otto Gas Engine. T Tanks.

PATERSON AND COOPER'S MEASURING INSTRUMENTS.

In an ordinary small engineering job, if there is no special need of scientific testing, measuring instruments, in the ordinary sense, are not required. There are the pressure and water gauges for the boiler, but with dynamometers and work and speed counters for the machinery we can usually dispense. With electrical engineering this is far from being the case, the agency being invisible, and no installation is nowadays complete without its ammeter, voltmeter, and speed-counter. Without measuring instruments the elec-

trical engineer works in the dark. If anything goes wrong he is at sea; but with proper instruments he can soon trace the fault. The electrical profession, as a whole, is not a little indebted to Messrs. Paterson and Cooper, who have taken up in a business spirit the clever inventions of Profs. Ayrton and Perry, Captain Cardew, and others. The new illustrated catalogue of these instruments has reached us, and we take the opportunity of drawing attention to the various points. The well-known Ayrton and Perry ammeters and voltmeters come first, with all recent improvements—simple form, calibrated in amperes and volts direct; or commutator form, with commutator in parallel, reading either direct or ten times the amount. Directions and formulæ are given for recalibrating. Electro-magnet ammeters, in which the values of the deflections are constant, measuring from 25 to 2,000 amperes, and rougher engine-room ammeters are also shown; and a combined portable ammeter and voltmeter, with leather shoulder-strap for use in testing installations. An extremely neat little voltmeter is illustrated with a dial and case about the size of a Waterbury watch, measuring from 1 to 10, or to 80 volts. It weighs 6oz., has a permanent magnet, and needle working in jewelled holes. The Cardew voltmeter has been slightly improved in small details, and by passing a current for many days through the wires before calibrating, it is ensured that they are perfectly stretched before sending out. In the Cardew voltmeter the indication is caused by the proportionate heating and lengthening of a fine wire; it has, therefore, no need of coils or magnets, and it is equally applicable to alternating as to direct current systems. It does require recalibration, and it is the only one that has the advantage, sometimes considerable, of being able to be kept continuously in circuit without injury. Prof. Thompson and Mr. Starling's universal photometer is illustrated in its arrangement for measuring both an incandescent lamp of 16 and an arc lamp of 2,000 c.p. Speed counters, galvanometers, and resistance-boxes complete the pamphlet.



Gravity-Controlled Engine-room Ammeter.

Combined Portable Ammeter and Voltmeter.

Simple Ammeter with Permanent Magnet.

Pocket Voltmeter.

Electro-Magnet Dead-beat Ammeter.

WOODHOUSE AND RAWSON'S SWITCH-BOARD.

This switch-board is intended to be used on an installation where the dynamo current is used to charge accumulators, besides being used for ordinary lighting purposes, &c. The centre switch is used when charging the accumulators, also when using them on line. It is arranged with a resistance coil on the two contact arms so as to prevent short-circuiting the cells when moving from one contact to the next, and also to prevent sparking. The moving arm is laminated, so that each section has an independent bearing upon the contact blocks, thereby ensuring full area of contact. The two side switches are of the G type, and are for the dynamo circuits.

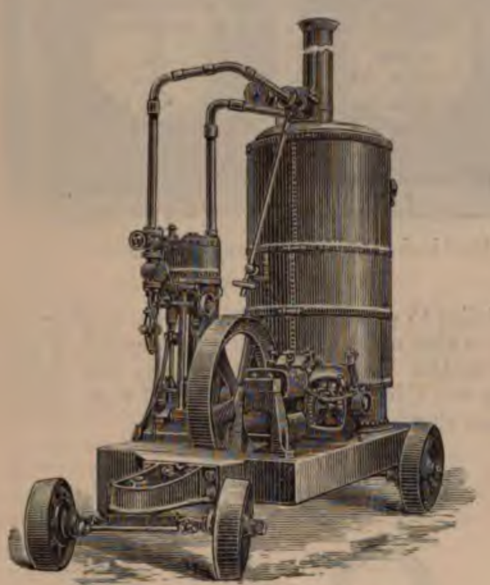
At the top are two magnetic cut-outs, which are arranged so as to automatically break the circuit should the current exceed the required amount. These with a slight modification can be made to break the circuit when the E.M.F. rises too high. The instrument at top in the centre is a resistance switch, which can be used for throwing resistance into the field-magnets of the dynamo. On the shelf at bottom is a voltmeter of standard type (see catalogue for description), with switch, so that the E.M.F. on line and at terminals of dynamos may be tested with it; also two ammeters of standard type, one for dynamo and lamp circuit, and one for accumulator circuit, so that the accumulators can be charging at the same time that the lamps are lighted.

The whole of the instruments are mounted on a slate slab, with name plates, &c. The permanent connections

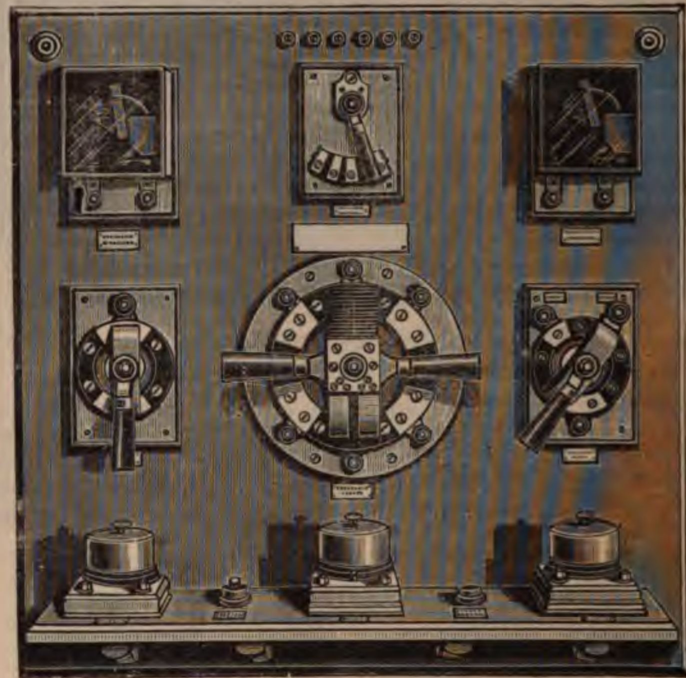
being made at the back, with copper strip, each instrument having copper connectors passing through the slate, and screwed and soldered to the copper strip, so that the switchboard, with the instruments upon it, can be fastened to the wall, and the cables connected to external terminals. The slate has a strong wooden frame at the back to keep it from the wall, and, if desired, the whole is enclosed in a strong mahogany case with glass doors, lock and key, &c.

PORTABLE ELECTRIC LIGHT PLANT.

The accompanying illustration represents a portable electric light plant made by Messrs. Paterson and Cooper for Mr. A. B. Simpson, of Bombay. The boiler, engine and dynamo are mounted on a strong cast-iron bedplate, provided with wheels, so that as a generating plant the whole is self-contained. The "Phœnix" dynamo is compound-wound for a difference of potential of 60 volts, and therefore suitable for burning incandescent lamps in parallel with arc lamps, or either separately. The boiler is 6 h.p. nominal, and steams at 80lb. per square inch. The engine is a 6in. by 6in. "Invincible," by Gwynne, of Hammersmith, and the dynamo, which is coupled direct to its crank-shaft, gives, at a speed of 350 revolutions per minute, 60 amperes at 60 volts.



Portable Electric Light Plant.



Wo dhouse and Rawson's Switchboard.

INSTALLATION BREAKDOWNS.*

BY REGINALD J. JONES, A.S.T.E.

It has been aptly said we learn more from our failures than our successes. In no branch of science does this apply more truly than to that of electrical engineering. A breakdown is, perhaps, the best practical test of the efficiency of the *man* part of an installation.

Speaking very generally of breakdowns, they may be divided into four great classes :—

1. The motive-power.
2. The electrical generating and storing plant.
3. The conductors.
4. The lamps and fittings connected therewith.

With regard to the first, it is outside the object of my paper to go into details of accidents in connection with steam or gas engines, turbines, &c.; but in passing it may be stated practice seems to point out that the best results as far as continuity of supply of current, for whatever purpose it may be required, is obtained by using several engines and dynamos instead of one large one, for with the latter condition it is simply a question of time before you have a breakdown. From an economic point of view it would seem, too, that the former is the best arrangement, as friction is proportionate to the load.

The following points are essential in connection with the management of long-running engines, shafting, &c.:—

1. Examine every bolt and nut, such as on eccentric straps, &c., before starting. Do not trust to luck.
2. Tap all cast-iron fly-wheels, riggers, &c., to see if they are cracked.
3. If there are joints in bands or splices, examine carefully before starting.
4. Have electrical heat alarms on the main bearings.
5. Clean and tighten all electric connections.
6. Provide a water supply over the main journals in case of need.

Prof. Thompson, in his admirable paper on "Diseases of Dynamos," pointed out the most probable sources of failure in these machines. From actual experience, it will now be my endeavour to tell you a few acute cases, with their symptoms, causes, and cures.

ARC DYNAMOS.

Firstly, we will consider some cases of arc-light dynamos failing to work, owing to faults (first) in the armatures, (secondly) the fields, (thirdly) the connections, and (fourthly) the driving-gear.

The machine we will consider first is a 16-light arc Brush machine. A short time after starting sparks were noticed on the outside of the armature coils when they passed the pole-piece, where the coil is cut out. These in a very few minutes became so big that the dynamo had to be stopped. On examination, the insulation between some of the wires on a coil was found to have been scraped away, and a small arc was formed. The spark only occurred when the coil was cut out of circuit, the extra current causing it then to jump the air-space. The cure was effected by blocking the wires apart and putting some tape, soaked in shellac varnish, to insulate them.

Another breakdown of a brush armature may be here mentioned. A 16-light dynamo, on being started with the circuit open, instead of showing very small sparks, kept up a continual flashing round the commutator; the cause of this was the breaking down of insulation between the wires of the armature coils in the bundle, and thereby causing a circuit through some of these armature coils—this generally necessitates a new set of wires connecting the coil and commutator.

* Paper read before the Old Students' Association, at the Finsbury Technical College, on May 29.

Connections.—In some large engineering works, a Brush dynamo had been running the lamps on the previous night well; but towards the end of the run some smoke was seen to come from under the wooden base, on which the copper springs, which connect the brushes to the outside circuit terminals and fields, are mounted. As is very often the case with non-electrical persons, the water-cure was tried, but naturally without success; and on the following night the machine would give no current at all. By short-circuiting from the brush to the terminal, so as to cut out the connection below, the dynamo started all right; the cause of the trouble was the nut clamping the brush spring to the wire connection below becoming loose and starting an arc. The arc carried the current all right as long as the machine was working; but on cooling down these metals were further apart, and coated with a poor conducting film having too high a resistance for the machine to build up current through it. A cure was effected by taking off the washer, scraping the dirty surfaces, and securing it in place again.

Another mishap coming under the head of connections occurred to a Brush dynamo running in a central station. The only symptoms were a sudden flashing over on the commutator, then total extinction of the lights. On stopping the dynamo it was tested with a detector to see if the circuits were intact. No deflection could be got by testing through the terminals of dynamo, but keeping the galvanometer and battery still on, and examining the wires which connect the fields, the needle was found to move when one wire was handled. Ultimately it was discovered that the tin sleeve joining the two wires had been placed considerably more on one than on the other. The solder which had hitherto held the wires in place was melted. Further tests showed a short circuit on the mains: thus, the lead acted as a fuse, and probably saved something more expensive to repair.

Driving.—One rather curious accident happened to an arc light dynamo, which was driven from a countershaft with a very tight short-drive belt. About half an hour after starting the night's work the machine flashed continuously at the commutator, the engine raced, and finally the belt was thrown off the machine. This was replaced, and a second time there was a repetition of the flashing and racing of the engine. On putting treacle on the belt and tightening up slides these troubles disappeared.

The cause was this. A sewn joint had been made in belt in the morning, and a new piece of leather introduced. This suddenly stretching, caused engine to race, dynamo to flash, thereby increasing racing of engine, finally causing belt to slip off dynamo pulley.

Driving Gear.—A fault in the driving gear of an alternating current machine assumed an uncanny bearing by appearing just at nine o'clock every night. The machine was driven by a gas engine and a leather link belt. To all appearances everything was in its normal condition, the lamps were up to full E.M.F., &c., but just at nine o'clock the belt began to run to one side of the pulley, and always ended by coming right off. This occurred for many nights in succession. At last we found, by putting some waste on belt as soon as the symptoms of running off occurred, the belt would run all right. At last it was found that the main bearing oil way was stopped, and all the belt surface became coated with oil about two hours after starting, thus causing the belt to lose its grip.

In the maintenance of high tension arc dynamos, the following are important points to be observed :—

1. Have the framework of the dynamo thoroughly insulated from earth.
2. Keep your commutator segments and brushes scrupulously clean.
3. Keep the commutators thoroughly wiped during running. Never use articles like sponge cloths to wipe commutator of open segment type. A case once came under my notice where this was done—the public did not think much of the experiment from a lighting point of view, and there were four brushes to straighten.
4. Keep the oil from getting in among the wires leading to commutators.
5. An automatic regulator on the fields reduces the risk of breakdown very much.

Arc Light Breakdowns.

By no means the most secure portion of a high tension system of lighting is that comprised under the heading of circuit. These may be divided into two distinct classes or types — viz., overhead and underground. In the former the chief risks are from breakage, due to stress of weather or flaw in materials used, accidental contacts of other wires, such as telephone, either causing a short circuit or damaging the instrument, and, lastly, liability to atmospheric electrical discharges. In big cities the continuity of supply is frequently endangered by fires breaking out. The advantages may be said to be cheapness of erection, ease of testing, and maintenance.

In the underground system the great danger is the difficulty of maintaining insulation and cost of putting down the system. The advantages of underground systems are the freedom from breakdown in heavy weather and stability, and certainly it must strike every mechanical engineer as being a better job. We will consider first a few cases of overhead breakdowns.

In an arc light circuit in some large engineering works, when the circuit was tested for insulation on a certain day, by bridge measurement it varied from 400,000 ohms to dead earth. The insulation would then remain high for half-an-hour at a time, and again vary intermittently from zero to the maximum. This went on for several days, until it occurred to me to test on a Sunday, when the works were stopped. On this occasion there was a permanent dead earth. After a little cutting of sections the weak spot was traced out, when it was found that a portion of cable had been dragged away from the cleats by a travelling crane, and was rubbing against a fast and loose pulley, the insulation being rubbed right through. When the cable rested on the belt there was good insulation, but when the belt was shifted to the other pulley it rested on the iron and gave dead earth.

In one case of arc lighting from a central station, run on the overhead system, the following occurred. On the previous day, the conductor was about 15 ohms, including lamps. The lamps ran perfectly well until midnight, the usual stopping time. On testing the conductor next day it was found to be 3,000 ohms. The fault could not be discovered by lighting-up time, so we decided at any rate to try what would happen by starting the dynamo, everything lit up as if 3,000 ohms, more or less, were a mere matter of detail. Afterwards, we found it really lay in a quadrant switch, which had become loose, the two contact surfaces were covered with little incrustations caused by the arcing. On the machine building up this spurious resistance disappeared.

In another long circuit of arc lamps, the circuit on being tested showed a perfect break of continuity, while at the same time the positive end of the cable gave good insulation and the negative a dead earth. There had been a heavy gale during the night, causing a lamp to become unhooked at one terminal only, consequently the chimney touched the iron hood, which was in contact with earth, while the unconnected terminal gave perfect insulation—hence the necessity of snap hooks.

A very curious phenomenon showed itself in connection with a series system of transformers on an alternating high tension system. There was a leakage to earth on the mains somewhere. On placing an incandescent lamp in series to earth in the engine-room, the filament was incandesced. As many as 18 lamps could be put in series, all lighting up with a very small difference in illuminating power to the single lamp. It would be of interest to know if others have observed a similar thing.

In dry climates, such as South Africa, they have to put comb collectors over the brushes of the dynamo, to discharge the atmospheric electricity from the line. In England, too, we occasionally suffer.

During a heavy thunderstorm a breakdown occurred on an arc light system of undergound wires. A portion of the lamps on circuit were suddenly put out. The lightning had struck a lamp-post, burnt out coils and lamp cut-out, then broke down the insulation of cable at two places, so that a portion was short circuited, thus cutting out a loop of the cable, with the lamps included in it. Still following up this subject of underground arc

circuits, the following is interesting in showing how the faults were eliminated. The symptoms were: The engine raced and dynamo flashed. On going round circuit a portion of the lamps were found to be out, and it was seen that No. 1 fault lay on the wire before No. 1 lamp. The dynamo was stopped, and circuit broken at No. 1. The dynamo was again started, so that current ran through faults only. We then followed line up by opening street boxes and tested for current with a compass needle, and found fault lay between two boxes. Dynamo was again stopped, and a temporary cable connected through overground.

Arc Lamps.

The arc lamps themselves are frequent causes of trouble in the circuit. The Americans call this the specific cussedness of the lamps; the minor faults are so numerous that they would fill a paper by themselves.

The following, however, is a somewhat curious example of some of the freaks of arc lamps. A set of 40 arc in a public building had been running very well for three or four months, when suddenly, night after night, lamps in various parts of the circuit would burn very dull red, get duller, and finally go right out. The dynamos were in good order, the current the same, and the insulation perfect of machines and circuits, yet sometimes as many as eight or ten lamps would be out together.

To discover the cause, a lamp was taken down low, and someone put on to watch its behaviour Then was noticed a sort of bubble of molten liquid collecting on the positive carbon, which trickled down into the arc. The lamp then gave only red glow, the globule gradually cooled and finally short-circuited the carbons. The difficulty was thus solved, for it was then remembered that a fresh batch of carbons had been used since the commencement of the fault. On changing these for good carbons we had no further trouble.

Let us now consider a few points in connection with low-tension systems.

Incandescent Dynamos.

Driving Gear.—A very puzzling, though simple, fault occurred in a compound dynamo, which had been running extremely well for several months, until one night when it was found that, with the full complement of lamps, only 20 volts could be obtained instead of 80. On running the machine light, the full E.M.F. was shown on the voltmeter. The circuits of the dynamo and those of the installation were tested and found to be in perfect order—the engine and dynamo were running at normal speed. Eventually, on going to take the speed at the commutator end, it was observed that the end of dynamo shaft and commutator were rotating at different speeds. On further investigation it was found that the commutator and armature, which were mounted on a sleeve, were slipping round the shaft, the set screws having slacked away. The load, of course, dragged the armature back, whereas when light it rotated at proper speed.

Connections.—A mistake in coupling-up led to a curious result with another compound dynamo—the direction of rotation was changed, and the shunt wires only were crossed. On running the machine light, with the pilot lamp only, the dynamo worked all right; but on putting the whole load on, as the series coil now worked against the shunt, the light may be best described as a minus quantity. We have yet another instance of faulty connections in the case of a new shunt dynamo installed, but all efforts failed to get it to build up. The insulation of the armature and fields was perfect, the field circuit was intact, and to all appearances the armature wires were not broken. There was no sign of sparking at the brushes at any angle, or any speed. The cause of this was that the field connections had been by mistake crossed and connected to the wrong terminals, probably after varnishing. Reversing these caused the dynamo to magnetise without further trouble.

Armatures.

We find that the armature is the part of a dynamo most liable to disaster. In series wound or compound dynamos there is great danger of an excess of current causing fusion or breakage should a short circuit occur. Another fault common to armatures is shown in the following breakdown. A small shunt dynamo, which was used for charging accumulators and driven by a gas engine, exhibited these symptoms; no current could be got through the cells, but the machine would run a few lamps direct. There was, however, continuous sparking at the commutator. On taking adrift a pair of wires on the commutator a break was found (by testing with a galvanometer) in one of the coil wires just where joined to the commutator. One circuit of the armature was always supplying current, and whenever the broken part passed the brushes, sparking occurred. On repairing this breakage the machine worked well again. The following, too, is an interesting case of the mischief damp causes. Two 300-light plain shunt dynamos were used to run an installation. They were run generally week and week about. After a week's idleness one dynamo refused to build up at all. On testing with a battery and detector the armature was found to be in connection with the shaft, and on further inspection was discovered to be quite damp. Then it was remembered that a pane of glass in the skylight above had been cracked during the week, and through it rain had dripped on to the machine. To restore the insulation a small current was kept on through the armature, the heat set up dried out the moisture, and the machine worked perfectly again.

Fields.—*Apropos* of the extremely bad habit of breaking the circuit of a dynamo by lifting the brushes whilst the machine is running, the following case shows the effect on the constitution of a machine. A four-pole shunt machine had been doing its work perfectly well for some time, until one night it was found impossible to get the full amount of light. The machine was taken to pieces, and a hole was found on one field burnt right through insulation consisting of three layers of calico steeped in paraffin, and the layer of paper and two holes were found on the other pole; thus short-circuiting a pair of limbs of the magnets. The attendant here had been in the habit of breaking the circuit with the machine running at a high speed.

Armature.—A very serious structural weakness of drum armatures is exemplified in the following case, which occurred to a compound machine running incandescent lamps. By some external means the mains were accidentally short-circuited; the main fuse went, but did not go before allowing a considerable rush of current through the armature. This caused the end band binding (made up of fine steel wire) of the armature to burst before the dynamo could be stopped; quite a number of sparks were seen at the pole-pieces, accompanied by a very strong smell of shellac burning. The pilot-lamp over the dynamo, however, burnt properly. On examination of the armature, it was found that the sparks were caused by loose steel wire ends striking against the pole-pieces; and the smell of shellac was probably due to heating of the wire by friction, and consequent heating of shellac on armature wires—the latter were quite uninjured.

In connection with the subject of bands breaking, a very novel accident occurred to a generator supplying current for a tramcar. The dynamo was a 300 volt shunt machine. The plant had been working well for some hours. On the first part of the journey the tram had to go up a stiff incline, while just before the terminus the incline was in its favour; the current at this point was switched off. The car completed one journey, but on trying to start again the machine would not build up; the circuits and insulation were tested with a galvanometer, and found in perfect order. The fields were then externally magnetised by a hand dynamo, all other means having failed. For a while the dynamo worked all right, but again broke down, exhibiting the same symptoms, except that now the field was broken. After the second stoppage it was found one of the armature-bands had broken, and the broken ends, in rotating, had cut through a field-magnet circuit. This, however, had fused together again, probably by the arc caused by extra current; but how the permanent magnetism of the poles disappeared was never made very clear.

These bands very frequently break. It would be interesting to hear from others what has generally been the cause of this—viz., bad mechanical fastening of ends, insufficient initial strength, fusion through contact with opposite sides of armature, or some such cause as the above first case.

Commutators.

The next part of the dynamo we will consider as a cause of breakdown is the commutator. As would naturally be supposed, the copper dust cut by the brushes and oil used in wiping the surface of commutator frequently give trouble. As examples of this fault, two cases may be cited—the first of a compound machine which, after running well for some time, began to spark very much, the armature becoming unduly heated. The cause was found to be copper dust and grease getting in behind the leather shield which covers right close up to the commutator, and causing a partial short circuit.

The second case was that of a series-plater, the commutator segments of which have air insulation below and between them. Here, after a while, a little mound of copper dust accumulated under the segments, eventually short-circuiting the commutator on to the steel shaft. To effect a cure the segments were removed and cleared. A second weak point is in the ring which clips the segments together at the end. Cases have come under my notice in which the insulation has broken down, and a short circuit established.

As Professor Perry in his recent lectures has shown us, the mechanical engineer seems sometimes to think that a dynamo being a new departure, old methods may be neglected and has strangely forgotten or left out precautions which he would in all other high-speed machinery adopt. The following case, bearing upon this point, came under my own notice. The makers of a well-known ring armature made their machine so that at the pulley end the inside face of the pulley was made to act as the distance-piece to prevent side play of the armature. The pulley itself was fixed on by a feather and secured at the end by lock nuts; these while running worked loose. The result was a general firework display and a job for the armature winders, for although an armature puts up with very little clearance at the pole-pieces nowadays, it draws the line at actual contact with the same.

We now pass on to consider incandescent lamps, circuits, fuses, &c

Incandescent Lamps.

Unlike arc lamps, the faults of incandescent lamps are not as varied. The principal causes of failure may be stated to be weakness of the glass bulb, which frequently breaks under atmospheric pressure; weakness of a portion of the globe at one point, as specimen exhibited; leakage at the points where platinum wires enter, and bad vacuum resulting therefrom; want of symmetry in diameter of filament, hence heating unduly at one point, causing rupture ultimately; want of stability of filament, causing it to fall to one side touching the glass and breaking it; deposition of carbon on the glass, &c. In very bad lamps the sudden expansion of gases has caused the globe to burst outwardly. The glass at point where the platinum enters sometimes cracks, due to imperfect contact and arcing.

Fuses.—No one will dispute the fact that the circuits of an incandescent system may be a source of danger to a building if not properly installed. As it is now a *sine quâ non* that all such work be protected from short circuit or leakage with fuses that danger is reduced to a minimum. It would seem to me that the system most likely to give best results in placing of fuses is one which reduces the number of these to as few as possible consistent with safety. By this is meant that there should be a double-pole fuse placed at the root of a branch so that the fuse will go should a current pass, by leakage or short circuit, which would dangerously heat the smallest wire on that branch. In the future it seems likely that double-pole magnetic cut-outs will be more extensively used for this purpose, as this form may be relied upon to go at a given current.

As an instance of the result of improper use of fuses, there is the not uncommon fault of putting in single-pole fuses indiscriminately. This has doubtless been the cause of some trouble, and one case came under my notice where a sub-circuit was burnt right out through this. From a well-authenticated source, the following very curious case, where combination of gas and electricity were responsible for some damage, has been given me. An ordinary lead wire fuse gave out through excess of current passing, and actually set fire to some gas which was escaping from a pipe close by. One great source of danger in an installation otherwise admirably protected by double-pole fuses arises from the fact that in these double-pole fuses both terminals of the mains are brought close together and bared. It would be far better, in my opinion, if two separate single-pole cut-outs were inserted, one on each main.

Alternating currents seem to cause molecular movement in wires. A case which came under my notice in a building, in the basement of which was a three-light electrolier, the lamps of which all began to flicker very rapidly; the cause was at last traced to the fuse, which was found to be working loose. From my experience of alternating currents, it seems that nuts always tend to work loose. Hence another reason for reducing the number of points of fuses.

It would be of great interest to hear if others have noticed the same phenomena more markedly in alternating circuits than in those of direct currents. As may be generally known, the fuses for the high-tension currents used for transformers are made of copper wire passed through sheets of asbestos, which are inserted to break the arc when the fuse goes. This asbestos seems to have a peculiar corrosive action on the copper wire, for at the points of contact the wire gets green, and soon eats away. *Apropos* of fuses and incandescent circuits, it would be of great value to all to hear of some authenticated cases of a fire arising from a minute leakage, but one not great enough to cause the fuse to go.

Insulation.—In concluding this interesting part of the subject, the following example of breakdown of insulation may serve as a warning to those who take what is sent them without making any tests. A whole floor of a large hotel had been very carefully wired, as far as mains were concerned, with a new cable laid in a wooden casing let in the joists, and on the wiremen completing the work the cable was tested to see if there was any sign of leakage. A very sensitive astatic galvanometer was used with a 200-volt chloride of silver battery. To their dismay, the cable showed a leakage of about 80 degrees—they were absolutely sure it was kept perfectly free from iron or earth contact. To find the fault the whole of the covering was taken up, and the mode of laying examined. Nothing could be seen, until at last it occurred to me to cut off a short length and test it. This was done by getting a fairly damp brick and laying the cable on top, putting one wire to the core and one to the brick.

The leakage deflection was reproduced, and on carefully overhauling the cable a small portion was found touching the brick work of one of the walls. It was then ascertained that a new outside compound had been tried on this cable in manufacture, which caused the insulation to be a partial conductor, and thus rendered it unfit for active service.

Automatic Leakage Detector.—It is often the case to find the insulation of an installation, which was at first many thousand ohms, fall rapidly from some cause or other after short use. I should like to make the suggestion here that a very useful piece of apparatus might be invented, and if made sufficiently cheap would no doubt be specified in all large installations to indicate at once when the insulation resistance of the mains fell below a certain point. This might be left permanently on the circuit on both mains, with an arrangement to call attention if the resistance fell below a predetermined point.

Conclusion.

It has been very difficult to make anything like a connected story of these chapters of disasters from the nature of the subject of the paper. I trust, however, that benefit may be derived from the simple enumeration of these defects and their causes. There are several instances of breakdown here quoted of Brush machines. The Brush dynamo I consider the best in the market, and that the instances, many of them from this class of dynamo, is simply from the fact that I have had more experience with this any other class.

In conclusion, I must thank several of my friends who have been kind enough to assist me with tit-bits from their own experience.

COMPARATIVE VALUE OF THE ALTERNATING TRANSFORMER AND CONTINUOUS CURRENT SYSTEMS FOR CENTRAL STATION LIGHTING.*

BY F. B. BADT.

We have heard three papers on apparently the same subject, though each of these papers was named differently by its author. I know a good many of you are under the impression that I will be an advocate of the alternating system against the continuous current system; but such is not the case. In the title I have given my paper I have narrowed this discussion to its proper limits. I do not believe, by any means, that the alternating transformer system will be substituted for isolated lighting, or for lighting within moderate distances; but I do believe that, for an economical central station lighting system, the alternating transformer system is the best in existence. This remark may seem superfluous; but lighting within short distances, and even isolated lighting, has been dragged into the discussion on this subject. Although the author of the first paper read apparently tried to show that the only practical system for central station lighting of to-day is the three-wire system of, say, not exceeding 230 volts, I propose to show to you that this attempt is not even consistent with the practice of the company this gentleman represents. In the first place, let me read an abstract of a circular concerning the Edison municipal system.

I quote: "The Edison municipal system has especially been devised to meet all the requirements of perfect outdoor illumination. . . . The current used in this system is of high tension (1,200 volts), which would be unsafe to introduce into dwellings, hotels, stores, or buildings of any character, where the wires and sockets are liable to be handled by inexperienced persons, but when they are stretched on poles in the open air, and the lamps are attended by persons who have been properly trained, all danger to the public ceases. If desired, the circuits for this system can be laid underground at a reasonable cost.

"Each lamp is screwed into a socket, which is protected from rain by a metal hood, and in the upper part of the hood is placed an apparatus that closes the circuit whenever a lamp carbon breaks, thus keeping the continuity of circuit uninterrupted. At the same time an instrument in the station indicates the breakage, so that the attendant may be sent out with another lamp to replace the broken one." N.B.—I hope he is provided with a bicycle.

Secondly, I will quote from a paper read by a gentleman during the Edison convention in Chicago, February, 1888: "A modification of the Edison three-wire system was mentioned where two Edison 600 volt, 26 ampere dynamos furnished current for several hundred lights; five 100-volt lamps being used in series on either side. The dynamos run without sparking. There is no more evidence of high pressure visible at this plant, or in the municipal 1,200-volt machine, than with 125-volt dynamos. There is probably no more perfect plant running than this, which has been in service since the middle of last year." And again, "Within proper limits, the principle of high pressure is not absurd or inconsistent with correct principles of future progress. The idea underlying the transformer is the logical outcome of experience, but thus far we have no satisfactory application to general commercial uses excepting possibly through the electric motor."

Now, in both cases, an electromotive force of 1,200 volts is employed, and they call the last-named system a "modification of the Edison three-wire system." If what we heard in the first paper is true, why does the same company employ an electromotive force up to 1,200 volts? The 1,200-volt three-wire system, as I understand it, is used for store lighting, and is introduced into houses, while in the pamphlet concerning the municipal system the introduction of 1,200 volts into houses is condemned.

Where is logic? Where is consistency? I cannot see it, but I hope that during the discussion, which probably will follow the reading of this paper, some of the gentlemen will be kind enough to explain it to me. I am well satisfied that there is a tendency, even among the most ardent advocates and admirers of the low tension system for central station plants, to occasionally raise the electromotive force when they cannot raise the necessary money to buy copper enough for their feeders and mains on the 230-volt three-wire plan. There is certainly less objection to even a 1,000-volt alternating transformer system than to the introduction of a 1,200-volt continuous current into houses.

Now, what I believe is, that all these systems, namely, multiple arc, three-wire, and multiple series *continuous* current, as well as multiple arc, multiple series, and transformer *alternating* system—are good in themselves, and that it is our task to find the proper places and the proper conditions for each. Each one has its place. We all agree that for isolated lighting, the multiple arc system is the best; whether continuous or alternating is a question which I do not want to answer here. For longer distances we will properly use, according to circumstances, multiple series of two lamps (three-wire) or multiple series of more lamps, again either continuous or alternating. And for still longer distances, we will employ a general system of incandescent lighting, where all points near and far must be reached in order to supply *all* customers—the *alternating transformer* system. These few remarks will probably outline my ideas of the application of the different systems of incandescent lighting under different conditions. What I want to show, however, to-night is the comparative value of the alternating transformer system and the continuous three-wire system for central station lighting. I will adhere to the points named in the previous papers, namely:—1st, first cost; 2nd, economy, efficiency, and depreciation; 3rd, reliability; 4th, variety and value of the possible sources of revenue; 5th, safety to life; 6th, effects upon existing property.

First and Secondly.—First Cost and Economy. Efficiency and Depreciation.

It was shown in the first paper that the cost of the conductors transmitting a given amount of energy at given loss for a given distance varies inversely as the square of the initial E.M.F. employed. Figs. 1 to 6 show the combined cross-section of copper feeders at five per cent. loss for 500 16-c.p. 110-volt lamps at a distance of one mile. They represent:—

[It is not necessary to show these sections. We give the diameter in inches.—Ed. *E. E.*]

Fig. 1, multiple arc. (110 volts, $3\frac{3}{8}$in. diameter.)

Fig. 2, three-wire system, according to Prof. Forbes (220 volts, 3in. diameter).

Fig. 3, three-wire system, according to H. Ward Leonard (220 volts, 2in. diameter).

Fig 4, five 110 volt lamps in series (550 volts, $\frac{3}{4}$in. diameter).

Fig. 5, alternating transformer system (1,000 volts, $\frac{3}{8}$in. diameter).

Fig. 6, alternating transformer system (2,000 volts, $\frac{3}{16}$in. diameter). The ratio is as follows:—

TABLE No. I.

Fig.	1	2	3	4	5	6
System.	Multiple Arc.	3-wire Forbes.	3-wire H.W. Leonard.	Multiple Series	Alternating Transformer.	
E.M.F.	110	220	220	550	1,000	2,000
Ratio of cost of feeders	320	216	108	13	4	1
Cost of feeders per lamp at 5% loss at one mile	\$71·00	\$53·00	\$23·00	\$2·80	\$0·85	\$0·21

I think this table is perfectly clear without any further explanations. I will repeat, however, the statement made by Mr. Slattery, that according to Prof. Forbes (*Cantor Lect.*), the saving of the three-wire over the multiple arc system is only 25 per cent., and that to assume any more saving may suit American financiers, but is not electrical engineering. The originator of the so-called Edison three-wire system (Dr. Hopkinson, of England) thoroughly coincided with Prof. Forbes in this view.

For the sake of argument, however, I will assume, whenever I speak of the three-wire system, the figures given by Mr. Leonard, or a saving of $66\frac{2}{3}$ per cent. over the multiple arc system.

* Read before the Chicago Electric Clubs, April 23, 1888.

Table No. 1 also shows the cost of feeders per lamp, at 5 per cent. loss, at one mile, assuming the cost of copper at 20 cents per pound. In Mr. Leonard's paper the parallel was drawn only between the 1,000 volt alternating system, employing 50-volt lamps, and the three-wire system, employing 110-volt lamps. I hardly think this fair, as it increases the cost of copper wires for the secondary circuits four times the cost of the copper wires in the branches of the three-wire system. In making this comparison the most economical alternating systems employed to-day in Europe and America should be considered. These systems employ an E.M.F. in their primary mains of about 2,000 volts, and use 110-volt lamps in their secondary circuits. Any improvement which in future should be made in these lamps will, of course, be an improvement in the alternating transformer system as well as in the three-wire system.

Now, in comparing the cost of the two systems, I will, for the sake of argument, again compare the three-wire system to the 1,000-volt alternating system. Let us assume that the cost of feeders per lamp at a certain distance for a 1,000-volt alternating system at 2½ per cent. the loss is one dollar. Then, according to Mr. Leonard, the cost of the copper for the three-wire system would be 27·50dols. Table No. 2 gives the cost of the two systems at 2½ per cent., at 5 per cent., at 10 per cent., and at 20 per cent. loss.

TABLE II.—*Comparative Cost of Feeders per Lamp.*

Loss in Feeders.	3-w re Syst m.	1,000-volts Alternating System.	Difference of Cost between the two Systems.
2½%	$27.50	$1.(0	$26.50
5 %	13.75	.50	13.25
10 %	6 87	.25	6.62
20 %	3.43	.12½	3.30

You can very easily see that the ratio in columns 2 and 3 is the same; but I want to draw your attention to column 4, showing the difference of cost per lamp in the two different systems under the conditions named. Suppose, now, that the cost of machinery, including boilers, pumps, engines, dynamos, house-wiring, and lamps in each case is about 15,000dols. for a 1,000-light plant. We would have to add in the three-wire system, figuring on 20 per cent. loss with full load :—

$$1,000 \times \$3.43 = \$3,430.$$

In the alternating system we would have to add—
$1,000 + \$12\frac{1}{2} = \$125$.

But we will allow five times this amount in order to enable us to get a wire of very high insulation. This would make 625dols. In addition we should calculate 3,000 dols. for transformers (3dols. per lamp). This would make a total of 3,625dols.

It must be borne in mind, however, that a pole line, or underground conductors for the three-wire system, would be much more expensive than for the alternating system for obvious reasons.

This would give us the following total result:—Total cost of 1,000 light three-wire system, 18,430dols. Total cost of 1,000 light transformer system, 18,625dols.

This would show the three-wire plant 195dols. cheaper than the alternating plant. But now let us make some calculations on 2½ per cent. loss in the feeders, and we find that the feeders for the three-wire system would cost $1,000 \times \$27{\cdot}50 = \$27,500$, and for the transformer plant 5,000dols. (again allowing five times the cost of copper for good insulation) and 3,000dols. for transformers, making total cost of 1,000 light three-wire system, 42,500dols. Total cost of 1,000 light transformer system, 23,000dols. This would make the transformer system 19,500dols. cheaper than the three-wire system.

You can very easily see the trick in this calculation. Take a certain amount of money as cost for the entire plant, excluding copper feeders in both systems, and also excluding transformers in the alternating system, and assume a comparatively high loss in feeders, the difference in cost for such feeders in the two systems will then appear as a small percentage of the total cost of the plant. Then assume a high efficiency of such conductors, say only 2½ per cent. loss, and the cost of such feeders will be a very large percentage of the total cost of the plant. You see in column 4 of table No. 2, that, though the ratio at different losses is the same, the difference in cost will appear very small when a large loss in the feeders is allowed.

This method of calculation is not electrical engineering, but is, instead, a calculation invented and probably patented by some selling agent who worked on commission. You can very easily see that if you want to sell a low voltage system, a high loss must be assumed, but if you want to sell a high-tension transformer system, a small loss in feeders is permissible and competitive with the low voltage copper mine system. Thus, you can make the total cost of the low voltage plant appear smaller or greater than the total cost of the alternating plant, as occasion may require. I very reluctantly make public this trick of the trade, but there is no charge for it to those gentlemen who should not have known it.

Now the question, of course, could be raised, why not figure on a higher percentage of loss in the feeders and still get the good results as shown in the first paper? I simply say this: Assuming a high loss in copper feeders is poor electrical engineering, it is a permanent waste of power; it requires complicated apparatus and permanent attention to keep the pressure alike in the different feeders with varying loads; it will cause greater lamp breakage, as necessarily, even in the best laid out system, the potential will very often rise in some of the branches far above the normal; it necessarily must be quite a complicated task of electrical engineering to get all the conditions right for best results. On the other hand, with a small loss and a nearly constant pressure kept at the main distributing points, all these difficulties disappear. The electrical engineering part becomes very simple, and lamps can be attached almost anywhere to the line without throwing the system out of balance. Simply the impossibility of advocates of the low-tension three-wire system inducing capitalists to spend money enough for such large conductors, as a small loss in the feeders would require, prohibits them from acknowledging all these advantages; and they necessarily must claim that it is good economy to lose more energy in the wires.

You can very easily see that the average load and loss question in table No. 1 of the first paper was simply introduced in order to make the loss appear smaller than it really is. Now, I think I can save a good many arguments by simply referring you to the picture which you behold here. It represents a low-tension three-wire system in Minnesota. The first pole near the station carries all the outgoing wires. There are fifty-four, varying in size from No. 0000 wire to No. 6. About one-half of the wires are No. 0000, and the remainder in varying sizes from 0 to 6. Don't forget to scrutinise this corner pole. Lamps of various c.p. are put up, whose equivalent amounts to about 7,500 10-c.p. lamps. The average number of lamps burning during the day amounts to 2,000, while the average number in use during lighting hours is about 7,200. The loss in these feeders amounts, with full load, to about 20 per cent. In one circuit it is even more. The claims, as far as economy is concerned, are ten 10-c.p. lamps per h.p., including the loss in the conductors. The station is equipped with 10 dynamos, five engines and boilers for about 1,000 h.p. There are 14 employés connected with the station. The coal consumption for 24 hours is about 53,000lb.

Now taking these data, and the picture before you, do you think that the theoretical tables and curves we had explained in the first paper were known to the gentlemen who laid out this station? The fact of the matter is that such a station as is illustrated can neither be economical nor on a paying basis. It can be only the laughing-stock of electrical engineers except those who own some stock in the concern.

A 2,000-volt alternating system would, of course, show up far better than a 1,000-volt system, as far as first cost and economy is concerned. Even granting that the efficiency of an alternating dynamo is not quite as good as that of the continuous current dynamo, and that a small percentage of loss will occur in the transformers, what are these in comparison with the enormous loss in the

feeders of a three-wire system, and the necessity of all the complicating balancing devices at the station necessary in that system ?

There is one point, however, which has not been touched upon, and that is that the whole calculation made in the first paper was based upon the fact that the number of lamps fed by different feeders was at all times reduced in the same proportion. I know, from practical experience, that in most plants this is hardly ever the case, and that resistance must be introduced to equalise the varying losses in the different feeders. This not only means waste of power continuously, but it also means wages of employés to watch the necessary instruments continuously, and to keep the different feeders balanced. So much for economy and efficiency. Of course, I do not want to repeat all the points covered in the paper read by Mr. Slattery, nor by the latest communications to the electrical journals made by advocates of the alternating system against the three-wire system as expounded by Mr. Leonard.

As far as depreciation is concerned, let me again draw your attention to the beautiful picture of the Minnesota three-wire station made by our special artist, and let me simply ask the question, Would you rather repair transformers, or would you prefer to keep a pole-line covered with a network of naked wires in repair ? Suppose customers did not renew their contracts for lighting ; which would be cheaper, to take a transformer and place it somewhere else, or have a high-priced electrical engineer sit down and calculate how to balance that line again, and take a couple of hundred lights from one place and transfer them to another point on the circuit ? These points, I think, naturally apply to the chapter headed "Depreciation."

I grant that well-insulated wire will depreciate more rapidly than bare copper wire, but for my part I would prefer to keep six well.insulated wires in repair than a pole-line with 54 naked wires as here illustrated.

Whether the depreciation of a high-tension dynamo is greater than that of a low-tension dynamo, is a question that can only be answered after more experience than we have had up to this time.

Thirdly, Reliability.—I can see scarcely anything in the corresponding chapter of the first paper which still needs answering. I certainly cannot see, that for the reasons given, a continuous current system is any more reliable than a transformer system. Again, let me draw your attention to the picture. I think that in the network of wires represented troubles are more likely to occur than in six well-insulated wires. Practical experience so far has not shown that the alternating transformer system is not as reliable in operation as the low-tension continuous current system.

That a switch-board in an alternating central station plant should be more expensive than a switch-board and the necessary apparatus to run a three-wire plant is something very surprising to me. I think that from what I have seen of the two systems, that the traps used in a three-wire station plant cost at least five times as much as those used in an alternating plant. What our contemporaries in Europe think of the reliability of the two systems will best be illustrated by the following examples :—

First—Milan, Italy, had a low-tension direct current 10,000-light station. To reach a theatre 6,500 feet off, they added a Zipernowski-Deri 1,800-volt alternating transformer system, using underground cables.

Second—Dijon, France. This town had a low-tension direct current central station, located in the centre of the town. The City Council regarded the noise of steam-engines, smoke, &c., in the heart of the city a public nuisance, and compelled the local company to go to the outskirts. The company abandoned the whole continuous system, and replaced it by a Zipernowski-Deri 1,800-volt alternating transformer system.

Third—Rome, Italy. A large central station is being erected, and is partly finished—all done on the Zipernowski-Deri 1,800-volt alternating transformer plan, with a capacity of about 18,000 lights at distances of 10,000ft. to 16,000ft.

Where is the low-tension plant reaching customers at such distances ? I could go on in this way *ad infinitum*, but I think these few examples will suffice.

Fourthly, Variety and Value of the Possible Sources of Revenue.—The question of increasing the income from the central station by renting out power has been ventilated before, and it has been shown that it is not by any means impossible to run motors on the alternating transformer system. It has been found, furthermore, that in practice it is advisable to run a separate circuit for the distribution of power. There is no objection to using continuous current dynamos for this purpose. It could be said that extra dynamo capacity would be necessary in such cases, but I hardly think this is true. It certainly cannot be expected that the same dynamo will run day and night in succession without ever stopping. I think that a certain reserve is necessary in any event. In the central stations I have seen only a part of the dynamo capacity is used during the day, and the whole during the main lighting hours in the evening, leaving no reserve whatever. If these same dynamos should be loaded, running motors all day, there would be in my opinion a continuous strain put on the apparatus, which is certainly not advisable.

I quote from the first paper the following :—"Then there is an almost unlimited number of applications of a continuous current on a small scale for such purposes as fire alarms, burglar alarms, distribution of time, annunciators, tickers, electro-plating, telegraph lines, and telephones, all of which rely upon a continuous current."

Now, I would like to have somebody tell me from what central stations such applications have been made on a large scale and on a paying basis. I do not know of any, and I think no central station would like to be troubled with these little nuisances. The amount of money which could be gotten as revenue for furnishing current to these appliances would certainly not compensate for the trouble they would continually cause. Therefore I must say that I cannot see that the alternating system is any more dependent for its revenue upon the sale of light alone than a continuous current system.

Fifthly, Safety to Life.—The danger to human life from high-tension alternating currents is always held up as a bugbear by the advocates of the low-tension continuous system. In the first paper it was stated that it has been conclusively proven in practice that a 1,000-volt alternating current is fatal to human life and will kill a horse. I do not know of any experiments made in that direction, but it would certainly be interesting to know how much larger an animal than a horse could be killed by a 2,000-volt alternating current. A telephone operator at Pittsburg, who was killed dead by the first paper with a high-tension current, while handling the switch-board at the telephone exchange, has come to life again in a communication to the *Western Electrician*. Maybe the same will happen yet with the horse. The fact of the matter is that at least ninety cases out of a hundred where persons have been killed by the high-tension current, death has been caused by the extra current set up in the field of a series dynamo when the external circuit was broken by the victim. Now, gentlemen, this danger does not exist in any alternating system.

The field of the alternating dynamo is separately excited, and such a powerful extra current cannot be set up and discharged through the body of the careless workman even in case he should break the external circuit. I therefore claim that the main cause for *fatal* accident does not exist in the alternating high-tension system. There is another danger which I think is greater in the continuous current system than in the alternating high-tension system. Just look at that picture hanging before you, again, and imagine a workman in that network of wires short-circuiting two of those heavy copper conductors by some means. The result would be a pound or so of molten and fused metal, which would not only inflict very severe wounds, but might even prove fatal. Quite a number of cases have come to my knowledge where persons have lost their eyesight or got otherwise mutilated by such accidents. You must remember that the wires of a low-tension system are mostly bare, while the wires of the high-tension alternating system are well insulated. It may be asked why, in the case mentioned, the safety strips would not prevent such an accident. I will say, that heavy fusible plugs melt rather slowly, and would not break the circuit in time to prevent the accident. The

smaller safety strips of the high-tension alternating system, carrying only a few amperes, would respond a good deal quicker, though, as mentioned before, such an accident is less liable to happen in this system.

Sixthly, Effect upon Existing Property.—Why a low-tension continuous system should be better protected by safety strips than a high-tension alternating system is a conundrum to me, and I refer to the discussion of this matter following the reading of Mr. Warner's paper. The inductive influence which might cause trouble to telegraph and telephone lines can be just as easily avoided in a transformer as in a low-tension direct current system. For underground work I think a cable would prevent all such troubles, and would furthermore prevent the retardation of the alternating system as explained in a brief article of mine published in September last. It may be mentioned here that wires carrying an alternating current are not in danger from electrolysis, and that the wires keep cleaner if fastened underneath ceilings or on walls. Wires carrying continuous currents will very soon show a layer of dust and dirt, which will appear as a demonstration of the magnetic whirls surrounding the wires.

In conclusion, I will give a *resumé* of the advantages of the alternating transformer system, as used for station lighting, in comparison with the three-wire system of distribution.

Advantages.—1. Location of central station plant need not be in the expensive centre of the city, but cheap real estate and power miles off can be utilised, thus decreasing the cost materially.

2. All customers near and far may be reached on a paying basis.

3. The price of conductors for feeders and mains is reduced to a minimum.

4. These wires being very small, the cost for poles and erecting lines, or of underground work, is materially reduced.

5. It does not take any great electrical engineering skill, or complicated calculations, to lay out such a system and make any alterations which may be necessary in the course of time.

6. The system is very simple, requires comparatively few stationary appliances, and fewer employés for regular running and repairs.

7. The small loss in the feeders will result in greater efficiency, more lamps to the horse power, smaller engines will be employed, less fuel consumed, and the earning capacity of the whole plant will be greatly increased.

8. It is easier to keep the electrical pressure constant, thus burning the lamps at all times at even c.p., and lengthening their average life.—*Western Electrician.*

PROVISIONAL PATENTS, 1888.

MARCH 27.

4673A. **Improvements relating to incandescent electric lamps.** Philip Middleton Justice, 55 and 56, Chancery-lane, Middlesex. (Charles Heisler, United States.) (Complete specification.) Note.—This application having been originally included in No. 4,673, dated 27th March, 1888, takes, under Patents Rule 23, that date.

MAY 18.

7399. **Optical telegraphy or spectro-telegraphy.** Henry Harington Leigh, 22, Southampton-buildings, Chancery-lane, Middlesex. (Paul La Cour, Denmark.)

MAY 19.

7463. **Improved alternating commutator.** Maxymilian Kotyra, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex. (Complete specification.)

7479. **Improvements in insulation in electrical machinery and apparatus.** Frederick Lawrence Rawson and William White, 1, Queen Victoria-street, London, E.C.

7480. **Improvements in insulation in electrical wire or in its supports or carriers.** Frederick Lawrence Rawson and Wm. White, 1, Queen Victoria-street, London, E.C.

MAY 22.

7487. **Improvements in electric switches.** Gus'av Binswanger, 5, Great St. Thomas Apostle, and Herbert John Coates, 6, Lawrence-row, Bow, both in London.

7519. **Improved portable easy chargeable safety fluid battery.** Ernest Getthardt Kempe, 22, Hamilton-street, Camden Town, N.W.

7522. **Dynamo-apparatus.** Edward John Houghton, 1, Pilkington-road, Peckham, S.E.

7523. **Means and apparatus for electric lighting.** Edward John Houghton, 1, Pilkington-road, Peckham, S.E.

7530. **A portable electric safety lamp.** Eason R. Chittenden and Ernest Edward Vaughton, Luchon, Kingston on-Thames, Surrey.

7536. **Improvements in galvanic batteries.** Benjamin Willcox, 47, Lincoln's-inn-fields, London. (Thomas Palmer Whittier, United States.) (Complete specification.)

7541. **Improvements in electric machines.** William Phillips Thompson, 6, Lord-street, Liverpool. (Henry W. Spang, United States.) (Complete specification.)

7548. **A floating telegraphic or telephonic station or apparatus for enabling ships at sea to communicate with one another or with the shore.** Urbain Dieuleveult, 47, Lincoln's-inn-fields, London, W.C.

7551. **Improvements in and relating to coupling devices for electrical and other purposes.** John Kendall and Owen Cooper, 45, Southampton-buildings, London, W.C.

MAY 23.

7585 **The combination of telephones with multiple signalling circuits.** Alfred Whalley, 2, Whitehead's-grove, Chelsea, S.W.

MAY 24.

7619. **A primary electric battery.** George James Weir, 22, Renfield-street, Glasgow.

7636. **Improvements in holders for electric incandescent lamps and shades.** Joseph Appleton, William Thomas Burley, and Albert Edward Williamson, Balmoral Buildings, 91, Queen Victoria-street, London, E.C.

COMPLETE SPECIFICATIONS ACCEPTED.

APRIL 18, 1887.

5648. **Improvements in apparatus for making and breaking electric circuits.** John Henry Holmes, 46, Lincoln's-inn-fields, London, W.C.

JUNE 24, 1887.

9017. **An improved method of heating ores and other substances by an electric current for effecting metallurgical, chemical, and other operations, and furnaces or apparatus therefor.** William Cross, 46, Lincoln's-inn-fields, London.

JULY 22, 1887.

10,240. **Improvements in field magnets.** Luther Hanson, Commercial-street, Halifax.

APRIL 11, 1888.

5362. **Improvements in arc lamps.** John Henry Holmes, Portland-road, Newcastle-on-Tyne.

5713. **Improvements in electric elevators.** John Keese Hallock and George Canfield Blickensderfer, 77, Chancery-lane, London, W.C.

APRIL 20, 1888.

5913. **Improvements in electric telegraph, telephone, and electric-light insulators.** Arthur West Heaviside, 7, Grafton-road, Whitley, Newcastle-on-Tyne.

SPECIFICATIONS PUBLISHED.

1887.

1333. **Oxydising and decomposing by electrical action organic matter, &c.** W. Webster. 8d.

6682. **Electrical distribution, &c.** J. Swinburne. 11d.

6993. **Signalling by electricity.** H. H. Slater and A. S. Newman. 8d.

7078. **Electrical indicators for gas-holders, &c.** P. Williams and W. Powles. 8d.

7426. **Preparing aluminium, &c., by electrolysis** A. C. Henderson (Heroult.) 8d.

7618. **Electric transformers.** W. M. Mordey and C. E. Webber. 8d.

8234. **Electro-deposition of the heavy metals** S. P. Thompson. 6d.

8380. **Operating tram-cars by electricity.** A. L. Lineff and W. Jones. 1s. 3d.

8466. **Low pressure motors.** E. G. Wastfield. 11d.

8737. **Motor.** J. W. Willans and J. B. McCulloch. 8d.

9011. **Dynamo-electric generators.** E. Jones. 8d.

14,542. **Electric motors.** W. D. Sandwell. 11d.

14,622. **Electric accumulator.** E. E. Vaughton. 8d.

15,907. **Photometers.** G. B. A. Gibbons and McEwen. 8d.

1888.

3678. **Electrical signalling on railways.** W. G. Olpherts 8d.

4561. **Battery jar.** C. A. Brown. 6d.

CITY NOTES.

British Association of Medical Electricians.—This association was registered on the 5th ult. as an unlimited company, without specified capital, to promote and encourage the study and practice of medical electricity.

Spanish National Submarine Telegraph Company.—The numbers are announced of 68 debentures, amounting to £6,800, of the Spanish National Submarine Telegraph Company, Limited, drawn on Monday last to be paid off at par on June 30 next at the National Bank of Scotland, Nicholas-lane.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	4
26 April	1%	Anglo-American	100	38¼
26 April	2%	— Pref.	100	64
12 Feb., 85...	5/0	— Def.........................	100	13
28 Mar.	3/0	Brazilian Submarine.........	10	12½
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	8⅞
12 April	2/6	Eastern	10	12
12 April	3/0	— 6% Pref.	10	14¾x
1 Feb.	5%	— 5%, 1899	100	111
26 April	4%	— 4% Deb. Stock	100	108
26 April	3/6	Eastern Extension, Australasia & China............	10	13
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	103½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5⅞
12 April	3/0	— 6% Pref.	10	13⅞
30 April	5/0	Great Northern...............	10	14

Dividend.		Name.	Paid.	Price. Wednesday.
1 Mar	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17
11 May	37/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	6x
16 Mar.	5%	Maxim Weston	1	⅛
26 April	2½	Oriental Telephone	11	$\frac{7}{16}$
26 April	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2¼
15 Feb.	15½%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40⅛
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	14⅞
......	...	West African..................	10	5
1 Mar.	5%	— 5% Debs.	100	92¼
29 Dec.........	6/0	West Coast of America ...	10	6⅛
31 Dec.	8%	— 8% Debs.	100	117
11 May	9/	Western and Brazilian......	15	10$\frac{5}{16}$x
11 May	6/10½	— Preferred	7½	6⅝
11 May	2/1½	— Deferred..................	7½	4
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	11¼
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 May	7%	West Union of U.S..........	$1,000	123
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of Mar. ...	£37,331	+ £1,376
Brazilian Submarine	W. May 18 ...	£5,326	...	Great Northern	M. of Apl. ...	21,400	...
Cuba Submarine	M. of Apl. ...	3,700	+ £736	Submarine	None	Published.	
Direct Spanish.....................	M. of Feb. ...	1,800	+ 119	West Coast of America	M. of Apl. ...	4,405	...
— United States	None	Published.	...	Western and Brazilian	W. May 18 ...	3,561	...
Eastern..............................	M. of Apl. ...	51,582	+ 8,446	West India and Panama	F. April 30 ...	3,268	+ 231

Abbreviations: W., week; F., fortnight; M., month.

COMPANIES' MEETINGS.

ORIENTAL TELEPHONE COMPANY.

The adjourned eighth annual general meeting of the Oriental Telephone Company, Limited, was held on Friday last at the City Terminus Hotel.

Mr. B. St. John Ackers presided, and in moving the adoption of the report stated that in preparing the accounts for the annual meeting on the 25th ult. they decided that until the Indian guarantees expired it would be better to keep the balance-sheet in the same form as before. Just prior to the annual meeting, however, the Board received an opinion of counsel respecting the legality of the payment of dividends by the former Directors, and thus, unexpectedly, the question arose as to whether the dividend now recommended of 2½ per cent. on the paid-up capital other than the vendors' shares could be paid. There was no no other course but to adjourn the last meeting, but the Directors had since taken the opinion of their legal adviser, as well as that of the Company's auditor, and also that of an eminent accountant unconnected with the Company, and they had been confirmed in their opinion that the assets were fully equal to the liabilities, and that the proposed dividend might be paid. His prediction at the last meeting had thus been verified; but it had been necessary to recast the balance-sheet, the revenue and profit and loss accounts, however, remaining unaltered. The patents and goodwill account had been written down by £42,990, and that item now stood at £71,000. Lower down on the asset side of the balance-sheet it would be observed that the deferred shares had been brought up and valued altogether, and the various sums had been carried out into one total. Now that the guarantees had expired, there would be no deferred shares in connection with the Indian companies; and the items of "shares and debentures in subsidiary companies" had been written up from £45,760 to £89,115. The total of the balance-sheet now came to £209,432, against £209,067 as shown in the balance-sheet submitted to the 31st December last—in other words, after the assets had been carefully valued and rearranged, it was seen that they were amply sufficient to meet all liabilities, with a small profit over of £365, thus increasing the item, on the other side of the balance-sheet, of sundry credit balances to £2,239. He therefore thought the shareholders would consider that the Directors were justified in recommending the proposed dividend, and he believed that the distribution next year would be sensibly increased. At the same time, it would be very unwise to divide everything, for they had no reserve fund, and they had no way at present of obtaining any extra working capital except by making a call on the shares. The vendors' shares amounted to £75,000, and were at present nominally £1 paid, while the other shares of £1 each had 11s. paid. He trusted it would be possible by some means to make an arrangement by which the vendors' shares should be reduced in amount, the liability on the other shares extinguished, and the vendors' shares rank very soon for dividend. If such an arrangement could be arrived at the shareholders would be a united body, and he was sure that that would be greatly for the benefit of the Company. He was glad to state that an agreement had been come to by which the Company's rights over the whole of Australia, New Zealand, and Tasmania were recognised, and by which they would also receive an annual amount in royalties. The one reason why they had not obtained all that they ought to have obtained was that the Melbourne exchange had been purchased by the Colonial Government.

The **Right Hon. G. Cavendish Bentinck, M.P.**, seconded the motion, which was unanimously adopted, and resolutions were afterwards passed declaring the dividend mentioned, and re-electing the retiring Directors and Auditors.

NOTES.

City of Mexico.—The plant here is being greatly enlarged, and it will soon be one of the best-lighted towns in America.

Paris.—The Prefect of Police having forbidden the use of gas at the Conservatoire at Paris, this hall will be lighted by electric light.

Senegal.—Saint Louis, in Senegal, is having the electric light. Senegal will be the first of the French colonies to be publicly lighted by electricity.

Long Life.—The American journals mention an Edison 16-c.p. incandescent lamp, first fitted on January 17, 1884, which has lasted 18,000 hours' actual lighting.

Prof. Bell in England.—Prof. Graham Bell was to have sailed for England on June 2nd, to attend before the Royal Commission on the instruction of deaf mutes.

Book Received.—"The Management of Accumulators and Private Electric Light Installations," by Sir David Salomons, Bart., M.A. Fourth edition, revised and enlarged. (Whittaker and Co.)

Sprague Motor Car.—Ten summer open cars have been started on the Richmond, U.S., electric road, 40 new men having to be engaged. Everything ran smoothly and without hitch, and 13,000 passengers were carried.

Strand.—At the last meeting of the Strand District Board of Works, Messrs. Dyson wrote, with copy of a letter from Messrs. Bircham, stating that this district had been struck out of the South Metropolitan Electric Lighting Provisional Order.

Electric Light in Every Cell.—The buildings of the Industrial Reformatory, Huntingdon, Pennsylvania, are fitted with modern improvements in the shape of steam heating and electric light. The 500 cells each contain an incandescent lamp.

Maxim-Weston.—It is announced that the "Watt" dynamo of the Maxim-Weston Electric Company, Limited, has now been officially added to the Government list as eligible for the lighting of Her Majesty's war ships, as well as for shore installations.

Electric Light on a Sandbar.—At Newport Harbour, U.S., the authorities have for some time felt the need of a better light, and arrangements are made with the torpedo station near to supply electricity for a powerful arc light to replace the present oil lamp.

The Bank of England.—The Bank of England have now had the 500 light installation at work some time, and are so far satisfied with the result that they have instructed Messrs. Drake and Gorham to proceed with the electric lighting of their new branch at the Law Courts.

Long Distance Telephony.—Experiments in long distance telephony (between Dijon and Marseilles, 500 miles) last week have been attended with very satisfactory results. Those between Marseilles and Noyes, a distance of 600 miles, are not so satisfactory, and are being continued.

Magnetic Iron Separator.—We are informed that this machine, about which we enquired last week, was exhibited at the Inventions Exhibition by Messrs. Ernest Scott and Co., the Close Works, Newcastle-on-Tyne, who have since sold some of the machines to the Government for the Arsenal at Woolwich.

Catalogue Received.—Messrs. Appleton, Burbey, and Williamson have sent us their catalogue, with illustrations of simple, neat, and cheap types of switches on china bases, and earthenware and slate fuses, and also china and ebony lamp-holders. Their address is Balmoral Buildings, 91, Queen Victoria-street, E.C.

A Pension to Reis.—We are glad to learn that the claims of inventors who have not worked their inventions to commercial success are sometimes recognised. Just before his death the late Emperor of Germany awarded to the widow of Philip Reis a pension of 1,000 marks annually, in recognition of the services of her husband.

Southend Pier.—The engineers of the new pier, Messrs. Brunlees and McKerrow, 5, Victoria-street, Westminster, propose to use electricity as the motive power for the tramway on the pier; the power to be generated by a dynamo driven by a gas-engine, placed in the arch beneath the approach. Question has also been raised as to electric lighting for the town.

Edinburgh.—The Streets and Buildings Committee of the Town Council, at a meeting held last week, has approved of the sub-committee's report, under which permission was given to the Anglo American Brush Electric Company to lay down wires in Rose-street for the lighting of the Princes'-street hotels and shops with electric light under certain conditions.

Cautious.—The Ministerial Council of Alexandria have just approved of the project for lighting the city by means of electricity, but only on condition that the contractor will hold himself responsible for all damages that the Egyptian Government might be called upon to pay to the gas company, should the latter deem it advisable to take legal proceedings against them.

Tenders for Bath.—According to advertisement appearing elsewhere in our columns, the Corporation of Bath ask for tenders for public lighting for a specified area with arc lights, either overhead or underground system, to be maintained by contractors at their own cost for a period of three, five, or seven years. Tenders to be sent to the Guildhall, Bath, by July 2nd.

Secondary Batteries.—A secondary battery has been patented by Mr. Ludwig Epstein, of Martinikenfelde, near Berlin, Germany. This invention covers a method of preparing powdered lead for electrodes, consisting in adding sulphate of lead to molten metallic lead, and stirring the liquid mass until it has been transformed into a finely-divided powder, with other novel features.

Belfast.—The Belfast Harbour Commissioners are considering the question of lighting the harbour, rendered necessary by the construction of a straight channel, and intend examining into the method of gas-buoys adopted at the Clyde. Why should they not use the incandescent electric lamps for this purpose—a method very satisfactorily adopted by the United States Marine authorities?

Gas Companies and Electric Light.—At Toledo, Ohio, the Gas Light and Coke Company have taken the bull by the horns in the enterprising manner recommended by us to English gas companies some weeks ago, and have fitted up electric light machinery sufficient to light the entire city. The installation is said to be a model of its kind; power is supplied at present by two 150 h.p. engines, and the steam is obtained by the surplus heat from the gas works.

Electric Torpedo.—A submarine torpedo has been constructed for the Spanish Government by Major Cabanyes, an officer in the Spanish Army, in which the motive power is furnished by an electric motor of 60 h.p., Brown-Œrlikon system, driven by a battery of 60 accumulators of a new type, about which absolute secrecy is kept. These accumulators have an extremely large capacity, and have been tested for some months by the Spanish Government with most satisfactory results.

Single Line Electric Railway.—The first public trial of the Enos system of single rail elevated electric railway took place at St. Paul, Minnesota, lately, according to local reports, with satisfactory results. The track has an average of 6½ per cent. grade, with many turns of short radius. The car, loaded with spectators, made many trips under complete control of a single operator. A speed of six miles an hour was maintained up the steep grade, and the system was pronounced a perfect success.

High-Pressure Boilers.—For some time past there has been a tendency amongst electric light engineers in America towards the use of higher steam pressures, as they find it advantageous in many ways, with their high-speed engines, particularly in the matter of economy of fuel. The Brush Electric Light Company, of Buffalo, are using boilers designed to carry a working pressure of 200lb. per square inch. Boilers have been supplied in some cases for a working pressure of 235lb., and are working perfectly satisfactorily in every respect.

Underground Wires in Philadelphia.—The Town Council have control of all electric wires, and some time ago they determined all overhead wires should be put underground, and this has now been completed. The Brush Company of that city have one wire five miles long working at a pressure of 2,800 volts; it has an insulation of three-thirty seconds of an inch thick, covered with lead one-eighth thick. The Keystone Company have also a fifteen-mile circuit working at 2,000 volts, and no difficulty has been found in working it.

Electric Welding.—The right of working the German patents of MM. Bernados and St. Olszewski, of St. Petersburg, is said to have been acquired by the Dresden Bank; while Rothschilds, of Paris, are reported to have acquired the exclusive rights for France, Belgium, Spain, Italy, and Austria. The invention relates to the direct application of an electric current for working metals, and more especially of forming alloys by the same method. The preliminary trials at St. Petersburg and at Crecil, near Paris, are said to have been very successful.

Belgium.—The Belgian Academy of Sciences has given the following questions for consideration at its meeting in 1889:—(1) Set forth and complete the state of our knowledge on the variation, in different solvents, of the electric conductivity of salts in different degrees of concentration; (2) Set forth and perfect the methods which are used to determine the elements of the terrestrial magnetism. Two gold medals, of the value of 800f. and 600f., are offered for the best solution of these questions, which must be sent in by the 1st of August, 1889.

Bohemia.—The town of Neuhaus, in Bohemia, has a central electric station established by Count Czernin, who is land owner of the district. The municipality have signed a contract for twenty years for lighting the streets with 85 incandescent lamps. The current is supplied by two dynamos driven by water turbines, and the wiring, on the three-wire system, is carried on poles along the streets. Private installations to the extent of 365 lamps are now in use, and the demand is extending. A battery of 1,000 accumulators is shortly to be put down to act in case of accident, and to ensure regularity of supply.

Bright Lights.—The electric lights on the Brooklyn Bridge are so bright that the pilots complain they cannot see, and ask for the old lights. Shades and reflectors will probably be put to diffuse the light. A curious accident from a similar cause occurred in Albany. A young law student and a lady friend were out boating one evening, and, when stepping out at the landing, the lady mistook the brilliantly-reflected shadow of the landing for the actual landing itself, and stepped into deep water. She was rescued by her companion after considerable difficulty, and now appreciates the fable of the dog and the shadow.

Machine Trench Digger.—A Minneapolis man, says the *American Engineer*, has invented a machine for digging trenches and sewers and gas or electric mains. The apparatus is 50 feet long, but can be made longer. On the front of the machine a four h.p. engine runs two knives, which do the digging. In the rear another engine, which furnishes the power for the apparatus, carries the dirt to that part of the machine, and drops it into the portion of the trench in which the pipe meanwhile has been laid. The trench may be of any reasonable width. Six men attend the monster. It has been claimed that 1,200 yards of pipe can be laid in a day by this machine.

Electric Coal Mining Machine.—A new coal mining company, known as the Electric Motor Company, which has a patent for mining by electricity, will establish a plant at Phillipsburg, Pa., for the mining of an area of 10 miles. The plant, as a whole, is to consist of a central dynamo, conducting wires, coal-cutting machine, electric lamps, and motor attachments for hanging the mine cars. The inventors claim, as an advantage in favour of their coal-cutters, that a single machine will not weigh more than 500 pounds. According to estimates, which, it is claimed, are made upon actual tests, the new device will considerably reduce the expenses of mining.

A Slap-dash Rule for Wiring.—Mr. H. C. Spaulding, Boston, writes to the New York *Electrical World* with reference to the recent rules for wiring:—"I should like to present for the consideration of the motor fraternity, the following 'slap-dash' rule for wiring. For a 400-volt circuit $H \times D = Cm.$, or number of h.p. to be transmitted, multiplied by the distance in feet, equals area of wire in circular mils. For 600 volts divide by 2. For 220, multiply by $\frac{10}{3}$, and for 110 by $\frac{13}{3}$. I will not say anything concerning the derivation of above; but, if any of your readers have objection to it, or can offer a more convenient and reliable rule, I should be glad to hear from them."

Gas Lighting by Electricity.—A very singular accident happened in Hamburg some weeks ago, according to the *Journal für Gasbeleuchtung*, which took a good deal of inquiry to find the cause of it. In an empty back room, behind a moulding, there were a number of electric light wires. A ½in. gas pipe was thrust through among these, and one of the electric wires was thereby broken. Its ends lay on the gas pipe, and melted a hole in the smith-iron pipe. As it happened, the gas was turned on, escaping while the electric current was off; then came the current and caused the explosion. The gas pipe bears distinct

marks of having been fused at the point where it was perforated.

Electric Lighting in Dublin.—The Corporation of the City of Dublin have applied, under the Electric Lighting Act, 1882, to the Board of Trade for authority to supply the city with electric light. The Lord Mayor, in his speech at the High Sheriff's dinner, asked the High Sheriff whether the condition of the public lighting of the city of Dublin was in a condition in which it ought to remain. He thought that neither in regard to cost, nor the character, nor the control, is the system of public lighting in Dublin satisfactory. Thus appealed to, the High Sheriff stated that, though a director of the gas company, he believed that the supply of light might be improved, and should be under municipal control.

Electric Exchange.—The New England Electric Exchange for granting licenses to electric workmen, about which we had a note lately, has met with considerable support from the insurances offices. We mentioned that the Fire Underwriters had announced their willingness to co-operate with the electrical contractors in the matter, but it appears they have thought well to go much farther than this. In the announcement just issued, the Exchange states that "after October 1, 1888, the Fire Underwriters will not insure any property where electric light or electric power is used, nor pass any new installation, unless the party operating the plant or making the installation has obtained from this Exchange a certificate of license."

Concession for Electric Lighting.—The municipality of a foreign city has asked Messrs. Osborn and Co., 6, Booth-street, Piccadilly, Manchester, to propose a scheme for lighting the town by districts, and to find a firm willing to take up a concession for a number of years to be agreed upon. The concession will be for—1. The supply and installation of plant and material for lighting the public buildings, streets, squares, &c. 2. The maintenance of the lighting for a term and for a price to be agreed upon. 3. The right to supply all the plant for the extension of the installation either for public or for private purposes. The installation to be redeemable over, say, 10 years, as may be afterwards arranged. Plans may be seen at above address.

House of Commons.—In committee upon the Electric Lighting Act (1882) Amendment Bill, Sir G. Campbell moved to add to clause 1 the following provision:—"When a local authority duly applies for a license for an area within its jurisdiction, such license shall be granted by the Board of Trade unless the Board of Trade are of opinion that special reasons exist why such license should not be granted, and in such case they shall make a special report stating the grounds of their refusal. The grant of a license to any company or person shall not in any way hinder or restrict the granting of a license to the local authority or to any other company or person, with the consent of the local authority, within the same area." Sir M. Hicks-Beach said the Government could not accept the amendment.

Office Lighting.—After two years' experience, the Prudential Assurance are still further extending their electric lighting plant, under the direction of Messrs. Drake and Gorham, who undertook the first design of the installation. There are at present two engines, each capable of giving over 100 h.p., and a similar engine is now being put down alongside the other two in the space previously occupied by the battery. The new battery is to consist of 264 cells made to Messrs. Drake and Gorham's specification, and patents by Messrs. Elwell-Parker, Limited, of Wolverhampton. In the first instance the installation was to consist of 1,000 lights as a maximum, so that there can be little question as to the rapid progress which has been made in the business of the Prudential Assurance Company.

Underground Cables in Lubeck.—The mains for the installation at Lübeck, for 20,000 incandescent lamps, are to be laid in a different manner than that heretofore employed in Germany, which has generally been cables heavily sheathed with steel wire. Those employed at Lübeck are to be lead covered, served with an outer covering of hemp, and laid in flat channels of rolled iron, with an iron lid. These channels are perforated at the bottom, so that any water may find its way out. By this means the mains can be laid close under the paving stones. Small junction boxes are used, with short sockets, into which the channels fit, and at the bottom of these sockets are ebonite plates, to which connections are arranged for fusible plugs. Separate testing wires are brought back from each feeding centre to the station.

Electric Bait.—The most *blasé* fish that ever wore scales and shunned a baited hook will draw near in thrilled wonderment to an electric light submerged in his native element, and so be allured to his fate. The United States steamer "Albatross" has been fitted with electric fishing lights for the conduct of scientific research, and preliminary experiments with these lights have revealed the fact that the curiosity of fish to investigate this unwonted radiance brings them to the light in shoals. The halt and the maimed of the *pisces* family turn out to see this wonder, and to capture them and all the rest is an easy task. A pocket-battery and a scoop net may become, says the New York *Electrical Review*, the successor of the can of angle-worms, the rod, and the minnow-bucket, but we fear the fisherman's enjoyment will be lessened.

Obituary.—Mr. Burchell, of the Sanctuary, Westminster, died suddenly on Sunday last. In the early part of the century he took an active part in the promotion of legislation relating to the great railway systems of the kingdom, and the settlement of many important questions in relation to the law of joint-stock enterprise. More than fifty years ago he was engaged with the late Mr. W. A. Wilkinson, for some time member for Lambeth, in the promotion of the Croydon Railway, one of the first lines connected with the metropolis, and now forming a portion of the Brighton and South Coast Railway system. About thirty years ago, with the assistance of Mr. Charles Pearson, at that time City Solicitor, he succeeded in bringing about the commencement of the Metropolitan Railway. He was associated with the late Mr. J. L. Rickardo in the promotion of the Electric Telegraph Company. The interment took place yesterday at Highgate Cemetery.

Derby Exhibition.—One of the principal features of the Industrial Exhibition, which has been held in Derby during the past fortnight, was the electric light exhibit of Messrs. John Davis and Son, of that town. The dynamo, which was a four-unit "Castle" machine, was driven by a three h.p. "Stockport" engine, and the lamps exhibited comprised a 2,000 c.p. and a 400 c.p. "Castle" arc lamp, with a 400 c.p. "Sunbeam" incandescent, as well as a few Edison-Swan 16 c.p. incandescents. The local gas company was ahead, and with commendable prudence had offered reduced terms to the exhibition on condition that no electric light should be allowed in the main hall, so that the lighting had to be confined to the entrance; but the arc lamp

in the archway leading to the hall was quite near enough to make the gas-lamps within look as sick as if they had lately returned from a rough trial trip on an oil steamer.

Large Motors.—The sizes and powers of electric motors are gradually becoming larger; we shall soon, we suppose, have motors driven by electricity capable of comparison with our locomotive or stationary engines of several hundreds of horse-power. The Œrlikon Foundry, of Germany, are turning out some large-size motors, one of which, a 60 h.p. motor, as reported from Spain, is used for furnishing the power for a submarine boat. At Ansonia, Connecticut, a freight (or, as we call it, goods) train is now working by means of electric motors, to connect the various large mills with the wharf. These are specially-built waggons, and are furnished with a 75 h.p. motor on a special motor car. The motors are of the Van Depoele system, and the road-bed being well and solidly constructed, the running is very steady and smooth, and has given every satisfaction, and the motor car pulls with ease all the cars they have at service. A single overhead conductor is used. The generating power consists of a 125 h.p. Corliss engine and a 100 h.p. Van Depoele generator and exciter.

Low-Tension System.—An interesting little central station installation is at work, says the *Bulletin de l'Electricité*, at Mende, in France. The installation was carried out by M. Lamy, who has established several other central stations in different county towns in France—Chateaulin and others. A continuous current is used at a pressure of 100 volts to supply Khotinsky incandescent lamps to a maximum distance of 850 metres (900 yards). The streets, boulevards, town hall, &c., are all lighted, and the hotels will shortly receive the supply. Engine-power is furnished for the evening lighting—that is, from dusk to midnight—by two 120 h.p. compound engines, driving direct at 120 revolutions, a Thuiry dynamo giving 800 amperes. The steam is supplied by Babcock and Wilcox multitubular boilers. These are stopped at midnight, and the night service is continued by accumulators charged during the day by a Gramme dynamo; this is driven by a separate 10 h.p. high-speed steam engine, and gives 40 amperes and 150 volts. This arrangement makes a very neat small central installation, and one that may be very usefully and profitably imitated in other small towns.

Electric Actinometer.—MM. Gouy and H. Rigollot, in *Comptes rendus*, give a description of a simple and easily made form of apparatus for measuring the intensity of light. They have found that a plate of oxidised copper submerged in a solution of chlorine, bromine, or iodine becomes extremely sensitive to luminous rays, even of the feeblest intensity, and can be employed as an actinometer. In a solution of sea water, two plates of copper, one of them being oxidised, have in total darkness an E.M.F. of some thousandths of a volt. When light is admitted, this E.M.F. increases, the oxidised plate becoming more positive. Two similar plates will equally answer, if only one is exposed to the light. Singularly, the variation of E.M.F. is more pronounced through a circuit of several hundred ohms. The experiment succeeds very well with a Deprez-D'Arsonval galvanometer; with a Thomson galvanometer the sensibility is greater still, the effect of a single candle at several yards distance being quite noticeable. The oxidised plate can be easily prepared by heating in a Bunsen flame. This apparatus is very easily made and employed, and may render many services in scientific experiments and other applications.

The Institution of Civil Engineers.—The Council of this Society has made the following awards to the authors of some of the papers read and discussed at the ordinary meetings during the past session, or printed in the minutes of proceedings without being discussed, as well as for papers read at the supplemental meetings of students:—For papers read and discussed at the ordinary meetings: A Telford medal and a Telford premium to Robert Abbott Hadfield, A.M.I.C.E., for "Manganese in its Application to Metallurgy," and "Some Newly-Discovered Properties of Iron and Manganese"; a Watt medal and a Telford premium to Peter William Willans, M.I.C.E., for "Economy-Trials of a Non-Condensing Steam-Engine, Simple, Compound, and Triple"; a Telford medal and a Telford premium to Edward Hopkinson, M.A., D.Sc., A.M.I.C.E., for "Electrical Tramways: The Bessbrook and Newry Tramway"; a Watt medal and a Telford premium to Edward Bayzand Ellington, M.I.C.E., for "The Distribution of Hydraulic Power in London"; and for a paper printed in the proceedings without being discussed, a Watt medal and a Telford premium to Prof. Victor Auguste Ernest Dwelshauvers-Dèry, for "A New Method of Investigation Applied to the Action of Steam-Engine Governors."

Tenders for Queenstown.—The Committee lately appointed by the Commissioners of Queenstown to consider the advisability of lighting Queenstown by means of the electric light recently had a meeting, at which the Chairman (Mr. Carbery) stated that he had obtained an estimate from a London company, who undertook to provide 40 arc lamps, with accessories, for £3,070. At present the town was lighted by 130 gas lamps, at a cost of £460 for gas alone. These lamps did not yield a light of more than 12 or 15 candles each—say, £2,480 candles altogether—while the 40 electric lamps would give a light equal to 80,000 candles. The Commissioners having this plant in their own hands, the supply of private consumers would be a very simple matter. So that instead of paying £460 a year for an illuminant, they would acquire a realisable asset capable of great extension. It was decided that tenders for the lighting of the town should be advertised for, such tenders to be considered by the Commissioners at their July meeting. The tenders are required for the public lighting of the streets, and also separate tenders for private lighting for the Queenstown Town Commissioners. Tenders are to be sent to Mr. James Ahern, Town Hall, Queenstown, by July 2nd.

Detroit Lighting Station.—Probably the most unique example of electric lighting is to be met with in Detroit. The entire city of Detroit, embracing 21 square miles, is wholly lighted by the tower system, and has been for four years past. The electric lighting plant, considered the most extensive in the world, is owned by the Brush Electric Light Company, and the whole is operated from one central station, many of the circuits being more than 25 miles in length. The Brush Company's works are of brick, and very extensive. A large boiler-room, 150ft. by 55ft., has ten boilers, and a railway switch track runs through in front of the boilers. Adjacent to this is a room 45ft. by 65ft. for large engines, in which there are two Wright-Corliss engines, 20in. by 42in. each, and one Cummer engine, 18in. by 36in. Beyond this again is a two-storey brick building, the first floor being devoted wholly to engines, and the second storey to dynamo machines. This building is 55ft. by 105ft., and the lower floor opens into the large engine-room above named throughout its whole length. The station is considered a

model structure, and has a capacity for 3,000 arc lights. There are employed for public lighting 122 towers of 150ft. each, with interior elevators, whereby the lamp trimmer ascends to attend to his lamps. The tower stands on a single pillar at the base, 14ft high, and above this is a straight trussed triangular structure.

Gas and Ventilation.—At the meeting of the London Section of the Society of Chemical Industry on Monday last week, Mr. Lewis T. Wright, F.C.S., A.M.I.C.E., general manager of the Nottingham Corporation Gas Department, read a paper on "The Present Position and Prospects of the Coal Gas Industry," in which he said that in the majority of cases the best burners for the ventilation systems of lighting were the regenerative ones. Regenerative gas lamps certainly required more attention than open burners; but this question of ventilating systems of lighting with intense burners was one that the gas industry itself had to solve. For the want of some efficient plan of this kind, electric lighting was displacing gas in many important installations—the sort of lighting that formed the backbone of the business, and would do so to a larger extent in the future. Gas undertakings themselves must engage in this matter; but it could not be done with any final advantage with the present staff. A new element would have to be introduced—an admixture of the architect and ventilating engineer. Speaking in regard to the cost of electric lighting, the author said it was impossible to secure a practical basis of comparison. He referred to the schedule of rates of an American electric lighting company, where the light was supplied on a time basis; and assuming the candle-power of the lamps to be equal to that stated by the undertakers, the cost per 1,000 candles per hour, supposing also the consumers worked the full time allowed under the particular rates, ranged from 8·3d. to considerably over 30d., according to the length of time the light was employed.

Pier-head Gas Lighter.—Mr. George Keillor, of Nairn, has adopted one of Messrs. Woodhouse and Rawson's electric gas lighters to the large Bray's gas burner on the Nairn pier with great success. In October, 1885, the lamp was lighted and registered as a coast light. Notwithstanding the fact that the light was all that could be desired, Mr. Keillor's troubles began. All went well until the first storm came on. The lamplighter dared not venture to the point of the pier to light the lamp, as the waves were washing over the structures; and yet it was just on such a night as that the light was needed. To avoid going to the point of the pier, Mr. Keillor arranged a burner with bye-pass, so as to burn at a low point all day; but, unfortunately, it only acted in ordinary weather, and was often blown out during the day. Besides, another great objection was the gas burning all day. This led him to adopt the electric gas-lighter, which he continued with an ordinary Bruce-Peebles meter governor. Mr. Keillor describes how he managed to do without carring a wire all the 500 yards to the point of the pier. He fitted a wooden box to the lamp-post at the pier-head, and he placed the battery in lower part of box. In the upper part he fixed one of D. Bruce Peeble's two-light mercurial governors, to which the gas-pipe going to lamp was attached. He then took the wire from the carbon of battery, and connected it to the brass spindle of bell of governor. The wires from the lighter in the lamp were taken down to the governor, and fitted horizontally across the cover of governor in such a way as to keep them a quarter of an inch apart—the one above the other, the lighting wire being uppermost. The wire fixed to bell of governor he placed at right angles to the other wires, so as to go through between them about half-an-inch. When the governor was at its full height, the wire from latter pressed hard against the top on the lighting wire, and the current was connected, and when the governor was at its lowest point contact ceased. By this arrangement the pier-head lamp was lighted.

About Patents.—Edison has been writing to the American *Carpenter and Builder* on the subject of patents, and gives it as the result of his experience that while it is a good thing to secure a patent, it is better to have a secret process. He says:—"The present law is a constant temptation to rascals. Under it the infringer of a patent is not interfered with until the real owner can show that he has the monopoly of the device in question. The process may take years, during which the infringer who has money and audacity enough to seize another man's invention can wear the righful owner's life out by litigation and annoyance. I have had so much of this sort of thing within the last five years, that I have almost made up my mind never to take out another patent until the law is changed. The burden of proof is now put entirely upon the man who wishes to infringe it, whereas it ought to be all the other way. There is scarcely any invention of importance made within the last generation which has not been disputed upon frivolous grounds, and the inventor put to all sorts of annoyance. In my own case I am sure that no matter what I may patent someone will come up as soon as the patent is seen to have any value, and show by dozens of witnesses, if necessary, that he is the rightful owner of the invention. If I patent to-morrow a process for making good flour at a cost of two cents a barrel, the publication of my patent would bring out about ten men who could prove that they did that sort of thing years ago, and that I had no right to patent. In the case of my dynamos, I have patents by the score, and yet when a great firm of machinists want to go into the business of making dynamos, they coolly appropriate one hundred of my inventions, and laugh at my claim as patentee. To litigate the matter to the end, if there was any end in sight, would cost hundreds of thousands of dollars and put me in hot water for some years to come. I am an inventor and not a lawyer, and I hate litigation. If patents are going to give me nothing but lawsuits, I don't want any more of them. I am so thoroughly convinced of the uselessness of patents that one of my objects in building my present laboratory is to search for trade secrets that require no patents, and may be sources of profit until someone else discovers them. There are scores of such secret processes which are enormously profitable, and which are not claimed right and left just because they are secrets. Some are used in this country, but most of them—chemical, chiefly—are held in Europe. Methods of dyeing, of working certain fabrics, &c., pay millions every year to those who know the secrets employed. I have one chemical device which promises to pay me handsomely, and the patent office will never hear anything about it. To apply for a patent would simply invite a lot of rogues to share with me, or, what is more likely, to take all the profits. I am rather curious to see what is to be done when the phonograph comes out. The patent has only five years to run, and evidently if men with millions behind them jump into the manufacture upon a large scale, the patent may run out before my claim to the fundamental device is allowed."

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 463.*)

MEASUREMENT OF RESISTANCES.

Differential Galvanometer Method.—The differential galvanometer has been already referred to as having, in some cases, advantages over the ordinary one. One of these advantages is the present application, in which its two coils are virtually used to form two sides of the Wheatstone's bridge. The peculiarity of the differential galvanometer and its mode of construction and adjustment will be fully referred to later. It consists essentially of two coils, which are so arranged relatively to a magnetic needle that when a current is passed through the coils they tend to turn the needle in opposite directions. It is usually so adjusted that the coils have equal resistance, and that, when equal currents flow through them, their combined effect on the needle is nil. Consider the arrangement shown in Fig. 22, in which *a* and *b* represent the coils of the galvanometer, *d* a box of resistances, and *c* a conductor, the resistance of which is required. The coil, *a*, and the conductor, *c*, are connected in series, and so also are the coil, *b*, and the resistance-box, *d*. These two pairs of conductors are connected in parallel, and form part of a circuit, through which a current from the battery, B, can be made to flow either in one direction or the other by means of the reversing-key, K.

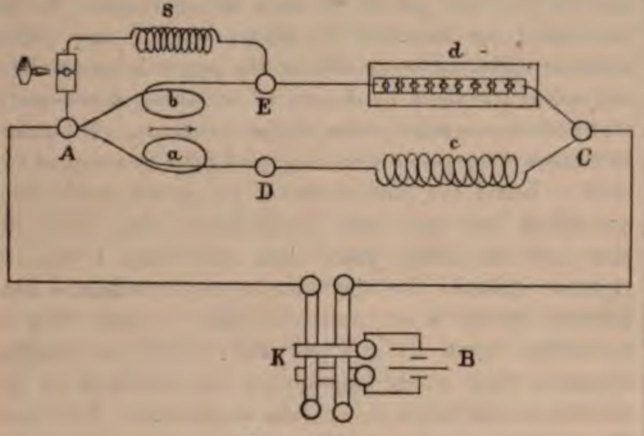


Fig. 22.

If now the resistance of *a* is equal to the resistance of *b*, and the resistance of *c* be equal to that of *d*, then resistances $a+c=b+d$, and the same current will flow through these two branches of the circuit. But when, and only when, equal currents flow through *a* and *b*, no deflection is produced, and the resistance of *a* is made equal to that of *b*. Hence, when no deflection is produced, the resistance of *c* is the same as that of *d*. There may be sensible disturbance of the result in this, as in most other resistance tests, due to thermo-electromotive force in one of the parallel circuits and not in the other, or due to different electromotive forces in these two circuits. The effect is never great when the difference of potential between the two ends, A C, of the parallel circuits produced by the battery, B, is comparable with a volt, and it is almost completely compensated for by taking the mean of the results obtained with opposite currents. As has been remarked above, the coils *a* and *b* are equivalent to two of the resistances, in the quadrilateral of resistances, forming part of the Wheatstone's bridge. This will become evident, if we imagine another galvanometer connected across between the terminals, D E, of the differential galvanometers which are joined to *c* and *d*. When equal currents are flowing through *a* and *b*, and consequently when *c* is equal to *d*, no deflection will be produced on this second galvanometer. It, in fact, occupies the position in which the galvanometer is usually placed in the Wheatstone's bridge. In the differential galvanometer method the equality of the current in the two arms of the bridge is directly tested; in Wheatstone's method their equality is inferred from the equality of potential at the points D and E. In both cases the galvanometric indication depends on the difference of currents in *a* and *b*, and with suitable instruments the sensibilities are similar. The case just considered corresponds to the Wheatstone's bridge with all the four resistances of the quadrilateral equal, and for this case the differential galvanometer is particularly well suited. When the resistance *d* cannot be made equal to *c*, one coil of the galvanometer requires to be shunted, and this case will now be considered; it is decidedly less favourable to the differential method. Suppose the resistance of *c* to be larger than can be got from the box *b*. A shunt circuit may be connected between the points A and E, as shown at S in Fig. 22, so as to take part of the current which would otherwise flow through *b*. Let the resistance of the shunt circuit be 1/9 of *b*, then, since the whole of the current which flows through *s* and *b* must flow through *d*, and the current through *s* must be nine times that through *b*, ten times as much current must flow through *d* as flows through *b*. But, as was explained in the previous case, the potential at D must be the same as that at E, and the junction C is common to *c* and *d*; therefore, by Ohm's law, the resistance of *d* must be one tenth of that of *c*. This gives a ratio of ten to one between *c* and *d*, and the same principle applies for any other ratio. Thus, if the resistance of *s* be made $\frac{1}{99}$ of that of *b*, the ratio would be one hundred to one, or, if instead of putting the shunt between A and E it had been put between A and D, the ratio would have been one to ten or one to one hundred, as the case might be, thus suiting low values of *c*. Theoretically, then, so far as mere arrangement is concerned, any resistance may be measured against a box of resistances, such as *d*, by means of a differential galvanometer. There are, however, other considerations which show this arrangement to be undesirable when high accuracy is desired. In the first place, the maximum current that can be sent through the coils of the galvanometer and the resistance-box is not great, and hence it is evident that when *b* is shunted, and consequently the current in *d* is greater than that in *c*, a very small current must flow through *a* and *c*. Small percentage change of this current cannot therefore produce much deflection of the galvanometer-needle. The same is the case when *a* is shunted, unless *c* be capable of carrying a strong current without heating much. It is then clear that as the ratio is increased, the sensibility is diminished in about the same proportion. In the second place, it is extremely difficult to insure that the ratio of the resistance of the shunted coil to that of the shunt will remain constant during the passage of the current for even the short time required to make the measurement. The current is not, of course, kept constantly flowing through the circuit, but several adjustments have almost always to be made before a balance is obtained, and this usually produced unequal heating in the coil and shunt, giving rise to a very sensible error. The very common practice of making the galvanometer coils of copper wire, and the shunt coils of German silver, may be noticed in this connection. If it were possible to estimate accurately the temperature of the coils of the instrument and of the shunt at any time, this practice would serve perfectly well, as, in that case, the ratio of shunt to coil could always be calculated from the equation, ratio $= \frac{G}{S} \times \frac{1+c(t'-t)}{1+c'(t''-t)}$, where G is the resistance of the galvanometer coil at temperature *t*, and *c* the co-efficient of its variation with temperature; S the resistance of the shunt at temperature *t*, and *c'* its co-efficient of variation with temperature, *t'* the temperature of the galvanometer coil, and *t''* that of the shunt at the time of the experiment. The temperature *t'* and *t''* cannot be estimated with sufficient accuracy, and hence it is better to make the shunt coils of the same wire as the coils of the instrument. In order to obtain perfectly satisfactory results, even when the same kind of wire is used for the coils and for the shunt, it is still necessary to insure that *t'* shall be equal to *t''*, and hence the shunt made for a galvanometer should be coils of the same size and shape, made of the same length of the same wire, and exposed to precisely similar conditions for cooling as the instrument coils are exposed to. These conditions never are, and cannot con-

veniently be, complied with in practice, and, in consequence, shunts should be avoided as much as possible in all measurements requiring a high degree of accuracy. For the measurement of very high resistances the coils of the galvanometer may have very considerable resistance without greatly altering the sensibility. In such cases the coils of the galvanometer and the shunts can be advantageously wound with German silver or platinoid wire. The very small variation of the resistance of these metals with change of temperature renders it possible in such cases to obtain considerable constancy and accuracy in the shunt ratio. For some special purposes, where the resistances are not very high compared with the resistance of a platinoid coil, better results may be obtained by using wire of phosphor bronze or aluminium bronze, all of which have a much lower temperature variation than pure copper. In all cases where the resistance of the galvanometer greatly influences the sensibility of the arrangement the galvanometer coil should be made of wire of pure copper. No advantage is obtained in this case by using an alloy, the resistance of which varies little with temperature, because the smaller the temperature variation the higher is the specific resistance in very nearly the same proportion. Greater battery power must therefore be used to obtain the same sensibility, and consequently the heating is just about as much greater as the temperature variation per degree is less. When lower sensibility is sufficient, it is usually better either to use less battery power or fewer turns of thicker copper wire in the coils thus by lower resistance insuring less heating. It is important to bear in mind that the answer to the question as to what metal may be used in the coils of a differential galvanometer to be used for the measurement of resistances is always obtained from a consideration of sensibility and possible electromotive force, other than that of the testing battery, which may exist in any part of the circuit. The sensibility must be such that the resistance may be measured to the required degree of accuracy, and for most purposes it should be such that a difference of one ten-thousandth between the currents in the two coils can be detected. Possible disturbance due to thermo-electric effect at junctions or other causes renders it necessary that the electromotive force used in the test should be much higher than any other which is likely to be in the circuit. When an unshunted galvanometer is used, an electromotive force between A and C of one or two volts is sufficient to avoid much error from this cause in almost all tests with the exception of telegraph line testing. When a shunted galvanometer is used, the electromotive force on the galvanometer coils themselves should be one or two volts. With good galvanometers having suspended needle systems, and especially with reflecting galvanometers, there is no difficulty in obtaining the required sensibility when such an electromotive force is kept on their terminals, and hence they should in all cases be made of wire having a low variation of resistance with temperature. The question of the choice between wires of different material for galvanometric purposes will be more fully and more advantageously discussed under the head of "Voltmeters."

(To be continued.)

PRACTICAL ELECTRICAL UNITS.

BY W. B. ESSON.

(Concluded from page 321.)

In the last article we considered the way in which dynamo and engine trials should be conducted, and observed that under the usual conditions of installation working we might expect 70 per cent. or so of the power indicated in the engine cylinders returned at the dynamo terminals.

It may be thought that the discussion of such questions is beyond the scope of articles professing to deal with electrical units, but, after all, the most important consideration is the price we have to pay for our units. Where electric lighting is concerned the coal bill is the all-important item in expenditure, and no excuse is therefore needed for bringing to the notice of the reader some further considerations regarding the circumstances on which its magnitude depends.

Boilers of the locomotive type are now largely employed for installation work, for which they possess special advantages. Steam can be raised rapidly with them when at work, and the expensive setting—a large item—in putting down Lancashire boilers is saved with this type. Their performance depends greatly on the way in which they are treated, and with good stoking it is possible to obtain first-class results; but the author's experience shows that a certain time must be served to attain proficiency even in stoking a boiler furnace. A man accustomed to Lancashire boilers generally has no idea of locomotive boilers, and none succeed so well with them as those who have been railway stokers. In ordinary working, a locomotive type boiler should, with good management, convert into steam at 120lb. pressure rather more than 9lb. of water per pound of Welsh coal consumed, the feed-water being supplied at a temperature of 60deg. F. As a matter of fact, an evaporation considerably over this amount has been frequently obtained; but if from year's end to year's end 9lb. are reached, the evaporative performance is all than can be fairly expected.

The amount of steam consumed per i.h.p. hour varies a good deal in different engines, and varies greatly in the same engine for different loads. Speaking generally, a non-condensing compound engine, loaded from two and a half to three times its nominal h.p., will consume per i.h.p. hour from 20lb. to 24lb. of steam at 120lb. pressure. We are not now speaking of competitive trials lasting for four or five hours, but of regular daily working. For this 22lb. is a fair amount on which to reckon, there being plenty of makers ready to supply engines which will not use more. Though the steam used per i.h.p. hours is diminished as the load is diminished, other circumstances arise to counterbalance this as we shall see presently. Meanwhile, we may assume that while running we consume $\frac{22}{9} = 2{\cdot}44$lb. of coal per i.h.p. hour.

When we make inquiries regarding the ratio of the power actually delivered at the crank shaft to the power indicated in the cylinders, the makers are far from ready to offer guarantees. As a matter of fact, very few makers know what their engines are capable of doing in this sense. They suppose they will give a brake h.p. of from 75 to 80 per cent. of the i.h.p., though in the absence of brake tests they cannot exactly say. Generally, the engine-building fraternity regard electric light men as a nuisance because they want to know too much. The former have put in, they will tell us, tens of thousands of h.p. with never a question asked regarding the ratio referred to, and now, forsooth, they go on because you want to light the mill, in which we have already placed engines of 2,000 h.p., by an engine of 100 horse or so; you would coolly put us to no end of trouble in rigging up absorption dynamometers. There is much to be said from the engine-builders' point of view, as the testing by brake of large engines is a very troublesome operation, but it is satisfactory to know that where tests have been made with brake and indicator simultaneously, the results have shown that from compound engines, loaded to two and a half or three times their nominal h.p., a net return on the brake of from 85 to 90 per cent. of the i.h.p. is obtained. This percentage increases as the load is increased, but, on the other hand, the steam used per i.h.p. also increases. The load stated is that for maximum economy, and we may, therefore, in ordinary working, reckon on a mean consumption of about 2·75lb. of coal per brake h.p. hour. It should be mentioned that at the recent competitive trial of engines at Newcastle the consumption was less than three-quarters of the above amount. But of course everything was then in first-class trim, and the trial maintained but for a few hours.

18. *Efficiency of the Dynamos.*—By the commercial efficiency of the dynamo is expressed the ratio between the electrical power appearing at its terminals and the mechanical power given to its pulley. Small dynamos by good makers may be reckoned to give a commercial efficiency of 85 per cent., while large machines may give 90 per cent. or even more. Since the armature and magnets have a certain resistance, there is always some electrical energy spent in the machine itself, and not available for use externally. The energy appearing between the terminals is in consequence from 90 to 95 per cent. of the total

electrical energy converted, and the ratio of the first quantity to the second quantity is termed the *electrical efficiency* of the machine. There is also power wasted in friction of bearings due to the weight of the armature in friction of brushes, in magnetic friction, and in generating parasitic currents. The whole of the energy applied to the pulley is not in consequence converted into electricity. To the ratio between the total energy converted and the amount given to the pulley the term *conversion efficiency* has been given. Until recently it was customary to measure by some form of transmission dynamometer the power given to the machine, but this method has been now abandoned in favour of methods in which the measurements are mostly or wholly electrical. Dr. Hopkinson's method consists in driving by a belt two similar machines, the shafts of which are coupled in line, one machine acting as a generator, and the other as a motor. In this way the greater part of the power driving the former is supplied by the latter, and only an amount equal to that expended in losses inside the two machines is furnished from an external source. The power thus furnished is measured by a transmission dynamometer, and the advantage of the method lies in the fact that this measurement—the only one about which there is any uncertainty—is a small fraction of the total power supplied, all other measurements being electrical. The liability to error of observation is therefore largely reduced, not to speak of advantages accruing from the possibility of testing large machines with a trifling consumption of steam. The accuracy of the method depends on the assumption that the losses arising from magnetic friction and parasitic currents are equal in generator and motor, though from the necessity of the magnetic fields being of unequal strength there must be some trifling difference in these. But while a small error is possible in the apportionment of the losses, there is no manner of doubt regarding the total efficiency of the system of generator and motor taken together, and a very great step in practical measurement was made when the method was demonstrated at the works of Messrs. Mather and Platt. A further step was made when Lord Rayleigh proposed to do away with the transmission dynamometer altogether, and furnish electrically the external power required either from a third machine or from accumulators.

But a simpler method than either of the above has been at a later date proposed by Mr. Jas. Swinburne. It may not be entirely free from theoretical objections of a minor character, but its extreme simplicity must counter-balance these, since they cannot be other than of trifling magnitude. In Dr. Hopkinson's method, two dynamos of equal size are required; in Lord Rayleigh's method there must be a third smaller dynamo, capable, however, of giving a *current* equal to the larger ones. In Mr. Swinburne's plan, in addition to the dynamo to be tested, a second smaller dynamo is required, which must be capable, however, of giving the same *difference of potential* as the larger one. To determine the efficiency, the field-magnets of the dynamo to be tested are excited by the small machine until the armature of the former, rotating as a motor, gives a back E.M.F. equal to the E.M.F., which as a generator it would give, turning at the same speed. The armature will take a certain current depending on the magnetic and mechanical friction overcome in spinning itself round in the field, this current being furnished by the small machine. The product of the current and the back E.M.F. Mr. Swinburne calls the stray power, assuming the total electrical energy appearin4 when the machine is fully loaded, *plus* the stray power, to be equal to the mechanical energy given to the pulley. Calling the stray power A, the loss due to the electrical resistances of the machine B, and the energy appearing at the terminals C, we have—

$$\text{Conversion efficiency} = \frac{B+C}{A+B+C},$$

$$\text{Electrical efficiency} = \frac{C}{B+C},$$

$$\text{Commercial efficiency} = \frac{C}{A+B+C}.$$

In an installation where there is a number of machines or a storage battery, the testing of the dynamo efficiency becomes then a simple matter, and by the above method a degree of accuracy is obtained far greater than by any transmission dynamometer.

Where there exist no means of furnishing current for the measurement of the stray power, recourse must be had to transmission dynamometers, of which there have been many designed from time to time. Generally speaking, they may be divided into two classes—first, those in which the driving belt is constrained in a definite direction, the constraining forces being measured and affording an estimate of the power transmitted; secondly, those through which the power is actually distributed, being received by one pulley and transmitted by another. In the latter apparatus the torque, or turning moment, is actually measured by the extension of springs, or by the balancing of weights against it. The dynamometer designed by Von Alteneck is the best known of the former class, having been very successfully employed for testing the efficiency of dynamos by Drs. Hopkinson, Prof. Adams, and others.

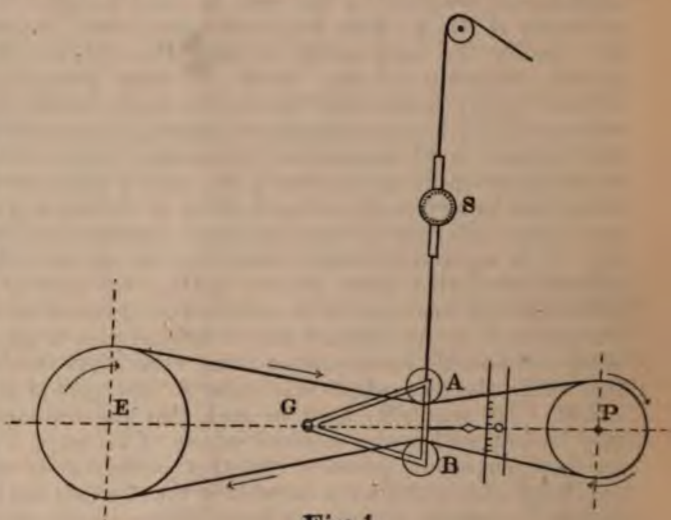


Fig. 1.

The sketch, Fig. 1, shows one form of the apparatus, E being the countershaft pulley and D that of the dynamo. A and B are two pulleys, mounted on the triangular frame A, B, C, which is free to move on a centre, C. If the motion is in the direction of the arrow, the bottom side of the belt being in consequence the driving side, it is easy to see that there exists a force tending to pull B and C downwards from the position shown. This force is counteracted by pulling A, B, C up, the pointer attached thereto being always kept at the zero position. A spring balance, S, indicates the force necessary to maintain the pointer at zero, and knowing this, the dimensions and the angles the belt makes, we can either trigonometrically or graphically determine from the triangle of forces the difference of pull on the two sides of the belt. A dynamometer of the form shown in the sketch can be made and rigged up with little trouble, but in its improved form the apparatus is self-contained, having the pulleys, springs, and index all mounted on a frame, which, being provided with guide pulleys, can be fixed firmly down to the floor when used for testing. There seems to be considerable difference of opinion as regards the accuracy obtainable with this dynamometer. In the hands of an expert who knows it thoroughly, reliable results may be obtained; but, on the other hand, great difficulties have been experienced from time to time by those who have not had previous practice with the apparatus. Many dynamometers on the same principle have been designed, but it is unnecessary to notice them here. In all the belt or rope is constrained to take a particular direction round pulleys, and the constraining force being measured, the difference of tension on the two sides of the belt can be therefrom determined. The difference in pounds, multiplied by the belt velocity in feet per minute and divided by 33,000, gives the h.p. given to the machine.

One of the best-known dynamometers, belonging to the second class, is White's. This apparatus, Fig. 2, consists of three mitre wheels, A, B, C, as on sketch; A and C being attached to the pulleys, D and E, which are gun-

metal bushed and free to turn on a pin, *a*, *b*. The mitre wheel, B, turns on a pin attached to the sleeve, F, the latter also free to turn on *a*, *b*. Prolonged to both sides of B is the lever, L, this and wheel being balanced by a counterweight, W. The action of the dynamometer is as follows. Suppose it to be interposed between the countershaft and the dynamo, the belt from the former running on D and to the latter on E, the power being thus transmitted from D to E through B. If the motion is in the direction

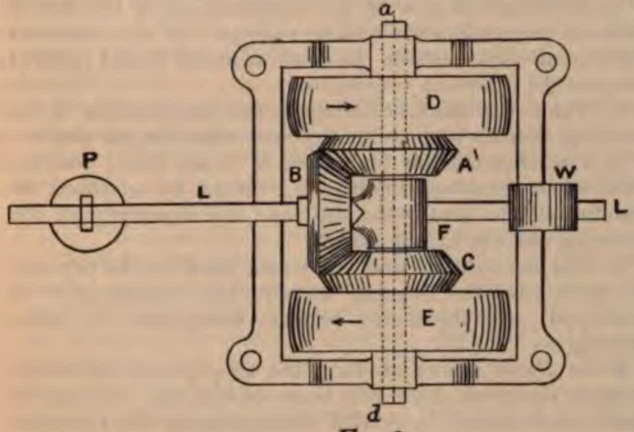


Fig. 2.

of the arrows there is a tendency to lift B, and this must be counteracted by a weight, P, placed on L. When the lifting force is balanced, the h.p. transmitted is evidently obtained by multiplying half the value of P in pounds into the distance in feet of P, from the centre of *a*, *b*, into the revolutions by 2π, and dividing by 33,000. Put in the form of an equation—

$$\text{H.P.} = \frac{P \times R \times \pi \times n}{33{,}000},$$

where R is the distance from P to the centre of *a*, *b*, and *n* the number of revolutions per minute. A modification of this dynamometer, proposed by the author, and which he considers an improvement, consists in substituting for the sleeve, F, and lever, L, a pulley, in the web of which the wheel, B, is mounted. A band is half wound round and attached to the rim of this pulley, its other end being fixed to a spring balance. The other end of the spring balance is fixed, and since for every load the pulley takes up a definite position, the value of P is at once indicated on the spring balance without the trouble of adjusting weights or maintaining the wheel, B—always in the same position. There are a great many forms of dynamometers belonging to the second class, which space will not allow us to describe here.

19. *Conclusion.*—We have considered the measurement of the power given to the dynamo, but the measurement of the power absorbed by countershafting is not such an easy matter. It must be noted that, whereas in measuring the efficiency of the dynamos by electrical methods we have excluded the friction due to the pull of the belt on the bearings, in the transmission dynamometer method this is necessarily included. It is evident that a correct measurement of the power absorbed by the countershafting can be obtained if we know the efficiency of the dynamo, and the ratio of brake to indicated h.p. given by the engine, but in the absence of such knowledge, unless we interpose a transmission dynamometer of some kind, our estimate of the power absorbed must be mere guesswork. The determination is difficult because the friction of engines or shafting loaded is a very different thing to their friction unloaded. It is a common practice to indicate the engines running idle, again driving the countershafting, and, thirdly, with the dynamos giving their full output, and to assume that from these indications we get the power absorbed by engine and shafting respectively when loaded. But this is incorrect, for when loaded the power absorbed in engine and shafting will increase, and the difference shown between the second and third indications will in consequence diminish. It has been proposed to employ as a dynamometer a steel rod of small diameter, which would form part of the shafting, and indicate by the twist produced on it the power transmitted; but the author is not aware of any results obtained from this form of dynamometer having been published. If we are content to treat the engine friction and friction of the shafting as one quantity, the power wasted is simply the difference between the i.h.p. and the h.p. received by the dynamo, and knowing the efficiency of the latter the determination is immediately arrived at; but if we wish to split this quantity into its two components for engine and shafting respectively, the determination must be necessarily a rather troublesome one. From the rough experiments which have been made, the power lost in the countershafting and belting—*i.e.*, from the engine fly-wheel to the dynamo pulleys, including the friction due to the pull of the belt on the latter—is from 10 to 12 per cent. of the engine brake h.p. Of course there must be great differences in different installations, but generally speaking—and we can only speak generally on such a subject—the above may be considered a fair estimate for these losses. It appears, then, that from a first-class compound engine and dynamo coupled direct an electrical return of 80 per cent. of the i.h.p. can be obtained. As before mentioned, this has been surpassed. From dynamos belted through countershafting a return of 70 per cent. may be confidently expected in ordinary working, while from those directly belted to the engine fly-wheel the return may be fairly assumed to lie between the two at 75 per cent.

THE TRANSMISSION OF ELECTRIC POWER.

BY HERR CÖRPER.

In the *Centralblatt für Electrotechnik*, Herr Cörper has described the Helios motor and system, also in the *Street Railway Gazette*, and from these the following abstract is taken:—

The employment of electrical propulsion for cars is more and more drawing to the front. In America, already in twenty towns there are electrical railways being worked. In England extensive trials are being made. On the European continent some lines are in activity, and last year the general attention of tramway companies was called to electrical gear, as the most convenient, elegant and cheapest means of locomotion, by an address by M. Michelet at Brussels.

According as the electrical energy is supplied to the car in motion from outside, or carried along with it in storage batteries, there are three questions to be solved. In the former case these are to be ascertained: the best way of supplying the current, the best construction of the motor, and a reliable kind of transmission between motor and car. In the second case these are to be found out: the best accumulator, motor, and transmission gear. I only intend to submit some remarks on the motor, the gear, and the accumulators.

Hitherto, almost exclusively, dynamos of high speed of the most varied construction have been employed as motors. They are usually fastened to the car frame, and transmit their power to the axle of the car by means of toothed wheels, friction wheels, belts, chains, wire spirals, worm wheels, gearing, &c. Immisch and Holt fasten the motor to the axle of the car, which is immovable, whilst the wheels run upon collar boxes. The one wheel is connected with a toothed-crown wheel, into which the small tooth wheel upon the axle of the dynamo fits. This gearing, however, does not answer, and in consequence a new method is being tried. From the search after the best construction of the motors, and the changing of methods of transmission, it can easily be seen that a thoroughly satisfactory solution of these questions has not been found. The reason for this lies in the nature of the matter itself. Only in the rarest cases with electrical tramways an uninterrupted run to a strictly defined distance can be taken into account. In such cases the management as it exists in the line near Schwabing may conveniently be resorted to, where the car at the terminus runs up an incline 18 metres long, is arrested at the top, and when restarting attains, by running down freely, a higher velocity before the electro-motor is set at work. Mostly, however,

a similar arrangement is impossible, because the car is obliged to frequently stop and restart without any regard to the construction of the line. Then the greatest efforts under the most unfavourable circumstances are asked from the motor. A firm coupling between motor and the axle of the car, for mechanical reasons, appears unavoidable, be it by tooth wheels, belts, worm-wheel gearing, or similar means.

Trials which were executed upon a line which was in the very best state and quite level, have resulted in proving that a certain car which, when in motion, will go over a distance of five metres per second with a traction-force of 120 kilogramme metre seconds, requires 345 kilogramme metre seconds for starting. With a worse state of the line, with risings, in curves, or when unevenly loaded, this proportion is more unfavourable. The electrical motor consequently, in order to comply with the requirements of working, ought to develop the greatest power when starting. This, however, with all constructions hitherto devised, is not the case. If the current, when the car stops, is made to circulate, the motor, in consequence of its firm coupling with the propelling axle, cannot but start very slowly. The supply of current, although such an excessive one, that the insulation is endangered, and the sparking upon the commutator great, nevertheless yields to the motor but a small fraction of the power which it develops with the normal number of revolutions and less current. The electrical tramway, as it has hitherto been constructed, therefore starts under the most unfavourable circumstances, and only when a certain speed of the car has been reached, the motor works with little current and greatest power. This, again, however, is just the stage of the working where the least force is necessary.

Furthermore, an inconvenience of the present arrangement arises from the mode of transmission. It is well known how great is the loss of power with worm-wheel and tooth-wheel gearing; not much less is the same with chain and friction gearings. The rapid depreciation of the single parts of such constructions, though made of the hardest and toughest material, sufficiently proves what power is lost thereby. Belts, wire spirals, &c., also show a considerable loss of force. This loss becomes the heavier the greater the speed of the motor. The inferior safety of the working offered by the accustomed modes of transmission, is also to be considered. It is known that interruptions are daily occurrences, that the expenses of repairs are very considerable, and that the interruptions of the working consequent upon the failure of the arrangements for transmission are regularly being attributed to the electrical parts generally, and not to the defective mechanical arrangements.

If we resume the practical results of the constructions hitherto used, we find that the motor must work under the most unfavourable circumstances when starting; that it has the least power and requires the most current when it requires the greatest power; that it develops the greatest power when it requires the least; that the mode of transmission entails a considerable loss of force, which happens to be greatest just when the least power is necessary; and that the mode of transmission is not only insecure, but also detrimental and very expensive.

If the propulsion takes place by accumulators, then the frequent damage which they are exposed to is to be taken into account. An accumulator is almost undestroyable, if the same is correctly charged and discharged. Every possible effort has been made to improve the accumulators, so as to make them fit for being used for tramways. Every good accumulator is suitable for this purpose. It is only necessary to not overwork it unreasonably. This, however, as long as the present constructions of motors and transmissions are being employed, always takes place as a matter of course.

Nothing hurts the accumulator more than a short circuit. When starting, however, if the motor is firmly coupled to the axle, the accumulator is short circuited, because the current which feeds the firmly-fixed motor is only moderated by the resistance of the copper, and not by the counter E.M.F. which the motor displays when it runs with the normal number of revolutions. It is an easy matter for the present state of the technical science to construct an accumulator for a run of 50 kilometres and to place it upon a car, but it is a thoroughly useless endeavour to improve the accumulator so as to make it stand being exposed to a short circuit, perhaps 50 to 100 times during a 50-kilometre run, as the working requires. Hereby the accumulators simply get out of order, just as well as the motor gets overheated and its commutator damaged by the fire on the brushes.

All these circumstances, which under the present arrangements offer the very opposite to what the electric working of railways needs, point with unresistible force to a fundamental change of the constructions, if the future shall see progress in the electric railway. If there were no electric railways existing, the machine-maker would perhaps propose the following programme:—

1. The motor must, according to the requirements of the working, display its maximum power when the car starts.

2. The transmission by means of worm-wheel gearing, tooth-wheel gearing, chains, &c., cannot be admitted on account of the great wear and tear, the insecurity of the working, and the loss of power.

3. The accumulator and the motor must not be exposed to short circuits, because hereby the accumulator is destroyed, and the motor becomes endangered by overheating.

From these points of view, the arrangement as subsequently described here has been constructed. It can be readily understood by careful observation of the reference letters on the accompanying cuts.

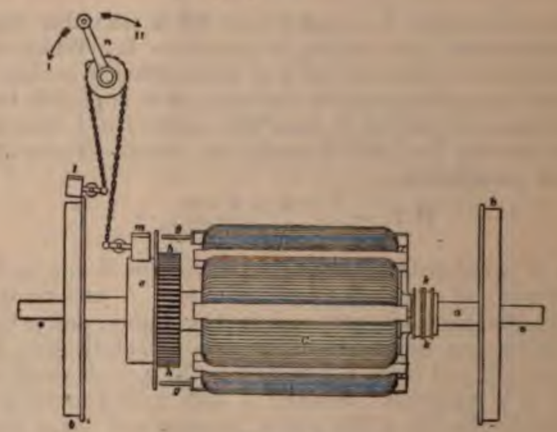


Fig. 1.

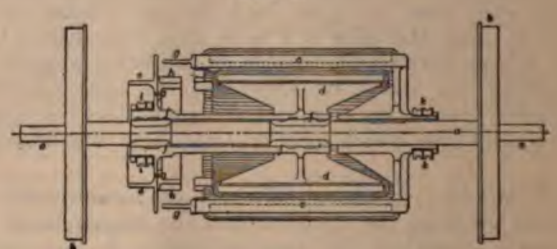


Fig. 2.

The magnetic field of the motor, C, is fixed upon the axle of the car (the propelling axle) itself, so that a turning of the magnetic field also involves a turning of the axle of the car. The armature shaft, *d*, with the brake-disc, *e*, is placed on a ram's-eye, *f*, which, by means of collar boxes, easily movable, is mounted upon the axle. The magnetic field bears the springs, *g*, where, as underneath these spring (*g*) the commutator, *h*, is fastened to the brake-disc, firmly connected with the armature shaft. Upon the outer ram's-eye of the brake-disc, *e*, there are placed two friction rings, *i*, by which the current is conducted to the armature, whilst near the magnetic field, C, upon the propelling axle, there are likewise placed grinding-rings (*k*), by which the conduct of current to and fro the magnetic field takes place. Upon the magnetic wheel, *b*, and the brake-disc, *e*, a speed-reducing gear, *l* and *m*, is attached, which, by means of a lever, *n*, is handled by the engineer of the car. If the lever (*n*) is turned to the left (I), then, by pushing the brake-block, *m*, against the brake-disc, *e*, the brake-disc, *e*, and the armature connected therewith, is arrested; vice versa, if the lever is turned to the right (II), then the car-wheel, *b*, becomes arrested, the brake-disc, *e*, connected with the armature, is completely

liberated, allowing the armature to turn perfectly freely. According to very accurate trials, made by myself, an electro-motor fitly constructed makes, with uniform supply of current, the same number of revolutions, no matter whether the magnetic field or the armature is made to turn. If armature and magnetic field are left to run simultaneously, both only make half the number of revolutions, whilst running in opposite directions. If, therefore, the axle, *a*, rests in boxes, *o*, one can, by arresting the armature, *d*, make the propelling power be exercised by the magnetic field, *c*, alone; or one can, by moderating the speed of revolutions of the armature, *d*, give to the magnetic field, *c*, and along with it to the propelling axle, *a*, proportionate velocity.

The effect now of the described arrangement is as follows: When the car stops, the brake upon the car must have been racked. Hereby the brake-disc, *e*, and the armature, *d*, are liberated. If the current circuit is now closed, the armature will at once attain its normal speed, because it can turn freely. A short circuit of the machine, or the accumulators, is therefore impossible. If the armature has its normal speed, the dynamo also develops its greatest power with proportionately little consumption of current. Should the car be started, the engineer must let the car-wheel be free. He therefore turns the brake-lever to the right. Hereby he arrests the brake-disc, *e*, and with it the armature, *d*. In the same proportion, however, as the speed of the armature, *d*, is slackened, the magnetic field, *c*, commences to turn, viz., in the opposite direction, so that finally when the brake-block, *m*, completely arrests the brake-disc, *e*, and with it the armature, *d*, then the magnetic field, *c*, alone propels the car with normal velocity. Should it be stopped, the engineer must turn the brake-lever to the left (I). Thereby he unties the armature; and because the same at once tends to take up the normal speed, not having to exercise any power, the traction force of the magnetic field at once ceases, and the brake can without hindrance stop the car-wheel.

It is clear that the braking gear can be varied in the most manifold manner, also be replaced by conical and other brakes. The predominating idea of this arrangement always remains this: *The firm connection of one of the elements of the machine with the propelling axle and the freely movable arrangement of the other element of the motor, controllable by a special braking gear.* The driving forward and backward is effected by changing the direction of the current to the armature. If we examine how far the described construction responds to the programme set up we find :—

1. The motor obtains when the current is closed, even if the car stops, at once its normal speed. It disposes, therefore, of its maximum power at the moment when the car, by pressing the brake upon the armature braking-disc, starts.

2. All intermediate gearing for transmission is obviated, because the motor is fastened to the car-axle itself and because it has the same velocity as the propelling axle.

3. Neither the accumulator nor the motor can be exposed to a short circuit when starting, because, before being able to do so, the brake on the braking-disc of the armature must be opened mechanically, and because the armature afterwards is not in any way hampered to at once assume its normal speed.

Against this construction there can be objected that the brushes or friction springs must turn round along with the magnetic field, and that the dynamo, because fastened to the propelling axle, can have but an inferior velocity, and consequently thereupon have but inferior efficiency. The first objection appears futile, because, whilst the train runs, it would not be possible to attend to the brushes. It does not matter, therefore, whether the same move or are fixed. The second objection leads at once into the syllabus of modern electro-technic, of which one dogma proclaims: "Slow-speed dynamos notoriously have less efficiency than fast-speed ones." I always ask, which dynamos? The slow-speed dynamos, built by the Society Helios at Ehrenfelt, Cologne, for 80 to 120 revolutions per minute, according to my construction, all possess an electrical efficiency of more than 90 cent. When running they hardly get warm. The copper winding has, when full current is on, but about 1 to 1·5 amperes per square millimetre sectional area of copper.

For the present the law of Ohm still rules, and according to that the current in all parts of a closed conductor is everywhere the same. According to my own practical tests, a copper wire coil of 2·3 mm. wire, when a current of 35 amperes passes it, becomes so hot that it can hardly be touched. It requires, therefore, a strong fidelity of faith, if thus constructed dynamos, which, in addition makes 1,200 revolutions, are not only mentioned in one breath with Helios machines, but as regards their efficiency are represented as far superior to the latter. It must always be asked, What machines are referred to? And as no electrician who will boldly state that fast-speed machines are better than slow speed has as yet taken the trouble to accurately examine one of the numerous practical constructions of the Helios Company, I think I have the right to say that the assertion, that high speed generally gives a better commercial efficiency, than a small number of revolutions, belongs to the domain of idle fallacies.

As things are, the objection against the employment of the slow-speed motors, mounted upon the axle of a car, can fittingly be brought forward only when a bad construction is concerned. This arrangement is, however, quite unobjectionable when a good machine, fit for the purpose, is being used. In a given case, which is represented in the accompanying drawings generally, the propelling axle of a street tramway is made the object. The diameter of the wheel is 750mm., the circumference, therefore, 2·35 metres. The car runs 300 metres per minute, from which there results a speed of 125 revolutions per minute. The dynamo for this number of revolutions is calculated as a current originating machine in series with an electrical efficiency of 86 per cent. I hardly believe that anyone, after examination of the relative circumstance in practice, would maintain that this arrangement gives an inferior commercial efficiency to any other fast-speed machine, the power of which must be transmitted by tooth-wheels, worm-wheels, chains, &c., from the axle of the armature upon the propelling axle.

I am of opinion that only the plainest views concerning the construction of machines can lead to practically good solutions on the field of electro-technics. The chief condition is to furnish good mechanical installations and arrangements. The race and the haggling about fractions of percentages of efficiencies has little value for practical purposes.

So I believe that the introduction of electrical railways will depend on efficiency, be furthered by the simple arrangements here described, because the same evade, as far as possible, those defects which the constructions hitherto used have shown.

THE ELECTROLYSIS OF MERCURY BY THE ACTION OF AN ALTERNATING CURRENT OF ELECTRICITY.

To the Editor of The Electrical Engineer.

Sir,—Perhaps it will be of interest to some readers of your valuable paper to know of the peculiar behaviour of two mercury electrodes placed a short distance apart in dilute sulphuric acid when an alternating current of electricity is passed from one electrode to the other through the dilute sulphuric acid. As soon as a current is caused to flow, the mercury becomes agitated and presents a beautiful wavy appearance on its surface, which increases in its agitation as the current strength increases; the mercury at the same being attacked by the acid, forming an insoluble sulphate, rises with the hydrogen, which is liberated at the surface of the mercury in a cloudy form, and slowly falls to the bottom of the cell. This peculiar phenomenon is of great scientific interest, as this sulphate is formed in proportion to the current passing, consequently the mercury loses in weight in the same proportion. We made these discoveries in the course of an extended series of experiments to overcome the difficulty of measuring alternating currents. Owing, however, to many mechanical difficulties in the use of mercury, the idea to use this as a meter was abandoned. Further searches resulted in a successful issue, and we hope to shortly publish an account of the working of our meter.—Yours, &c.,

Lowrie-Hall.

THE

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TO CORRESPONDENTS.

 Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering, which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

ELECTRIC TRAMWAYS.

It is one of the tenets of political economists that as soon as a certain thing is generally wanted, production steps in and supplies that want. Applying this doctrine to electrical engineering, and especially to electric tramways, we may reasonably suppose that if it be clearly established that there is a demand for motors, gearing, batteries, conductors, and all the accessories of electric propulsion, these things can be had by the simple process of applying to those persons competent to design and construct them. The problem of electric tramways is not beyond the capacity of electrical engineers, as is amply proved by the various lines already in successful operation. The supply is fully up to the demand and more. Special systems are continuously being brought forward for which there even is no demand. Why inventors should go out of their way and design complicated pieces of apparatus to perform a certain kind of work which can perfectly well be done by simple machinery already practically tried, it is difficult to say. In all probability Mr. So-and-So's special system has been simply designed with a view to bring out some distinctive novelty, or is a fad of Mr. So-and-So's which he will find it difficult to justify before competent engineers. He may have a theory of his own by which he makes his design appear plausible to the general public, but as to giving an intelligent scientific account of the why and wherefore, such as engineers can appreciate, this is not in his line.

The total length of electrically worked roads in Great Britain was in the autumn of last year about 22 miles, and this includes a telpher line and an electric railway or two. At present the total mileage worked electrically does probably not exceed 18 miles, and if we except the Stratford and Manor Park line, none of the others have any special system, but each is designed with due regard to local requirements, and on the whole they work satisfactorily. As regards the line just mentioned, there can be little doubt that if the "special" and, to our mind, uselessly clumsy and heavy gear were replaced by the ordinary spur wheel and chain, it would be an improvement. But, after all, this system must be considered simple as compared with two others recently brought forward. The one is the Jarman system, and the other that devised by Mr. Coerper, of Cologne. The novelty of the former consists in the employment of a duplicate machine, one armature being used when the car is travelling in one direction, and the other when it is travelling in the opposite direction. This is done to prevent either armature getting too hot, a contingency which Mr. Jarman anticipates if one armature only were used continuously. Now there are many dynamos which must be kept running day and night for weeks together, and yet their armatures keep in good con-

dition. Motors are often worked for 10 and 12 hours at a stretch, and if it be remembered that upon the durability of a big transmission plant the working of a whole factory may depend, it will be easily seen that the chances of failure must be exceedingly remote, otherwise no practical engineer would take the risk of recommending, nor a shrewd business man that of adopting the electric transmission of energy for every-day commercial use. Viewed in the light of experience, Mr. Jarman's special system appears therefore to be a device to overcome a difficulty which does not exist; whilst at the same time it is more complicated than any of the designs which have already been found to answer in actual practice.

The motor and gear proposed by Mr. Coerper is also intended to overcome an imaginary difficulty—viz., that of too big a current at the start. In this design the armature is keyed on one of the car axles, and the field is capable of revolving round the same centre if not held by a brake. The theory is as follows:—In the ordinary arrangement, upon first turning on the current, the armature cannot immediately acquire its full speed, and an excessive current must pass until the car is fairly started. Now in Coerper's arrangement, although the armature cannot start any faster than the inertia of the car will permit, the field (when the brake is released) can start off in the opposite direction, and therefore the relative speed of armature and field is very quickly obtained. Consequently there is almost at once sufficient back E.M.F. to prevent the passage of an excessive current without its being necessary to insert artificial resistance into the armature circuit. The brake is then slowly tightened, thereby bringing the field gradually to rest and accelerating the armature until the full speed has been reached. All this sounds very pretty, but is misleading. To start the car in a given time—that is, to impart to it a certain acceleration—a definite torque must be exerted by the motor, and this requires a definite current through the armature. Whether the latter be revolving slowly or quickly has nothing to do with the starting power, which is simply a question of current. There is therefore nothing gained by allowing the back E.M.F. to rise at once. Mechanical work must ultimately be wasted in the friction of the brake which brings the field to rest, just as mechanical work is wasted in heating the artificial resistance inserted at the start with the motors as usually constructed. But there is this difference: in the usual type of motor the apparatus used to protect the armature from an excessive current at the start is a plain resistance coil and switch; in Coerper's improvement (?) it is a moving mechanical device entailing considerable complication.

We have alluded to these various devices, not so much to show that they present no special advantages, as to point out the lesson they teach; and this lesson is that inventors are still casting about for some means by which to get "more power." When mechanical engineering was yet in its infancy, many inventors spent years of their lives in vain attempts to devise some cunning combination of mechanical elements by which to multiply power, and now it is as though some electrical engineers were pursuing a similar course. Hitherto nearly all the failures of electric propulsion have been due to the fact that the designers of the apparatus had under-estimated the power required, but the remedy should not be sought in special and complicated contrivances. There is only one remedy, and that is to make the apparatus strong enough in every detail and of ample power, whilst retaining for it the most simple forms which practice has shown to be efficient.

Now what power should be provided? The tractive force on an average tram-line, exclusive of that due to gradients, is about 25lb. per ton of rolling load. We may take the weight of a large car filled with passengers, and including the weight of motor and gear, to be from 6½ to 7 tons, and if it contain accumulators, from 8½ to 9 tons. These figures are slightly higher than generally assumed, but as we advocate motors and accumulators of ample size, they will not be found very wide of the mark. Assuming the speed to be 7 miles an hour, the work done on a fair, level road would be 3¼ and 4¼ h.p. respectively, or say 4 and 5¼ e.h.p. to be supplied to the motor. But the roads are not always in fair condition. The grooves of the rails are often filled with dirt, the rails are worn so that the car rolls occasionally on the flange of one wheel and the face of the other, whereby a grinding action is produced, power is also wasted on sharp curves. To provide for these contingencies an allowance of 50 per cent. at least should be made. This brings the power up to 6 and 7½ e.h.p. respectively. A further allowance must be made for gradients. A rise of one foot in a hundred increases the tractive force required by 22·4lb. per ton. Say that the steepest part of the line is 1 in 30. In this case we would have to add another 10 and 13 h.p. respectively, making a total of 16 e.h.p. for a car worked on the conductor system, and 20½ e.h.p. for a car worked on the battery system. These powers are not required continuously, but the machinery must be capable of supplying them at certain times. There is, however, another allowance to be made. To start a car, the tractive force exerted may rise as high as 120lb. per ton, especially if the start is made on a bad part of the road containing a sharp curve. Add another 66lb. for the rise, and we have a total of 186lb. per ton, to overcome which the motor will have to exert a torque which, at the full speed of 7 miles an hour, represents 30 and 39 e.h.p. respectively. Since these large powers have only to be supplied for very short intervals, it is not

necessary that the wire on the armature and the series wire on the field should be designed to continuously carry the corresponding circuits. It is quite admissible to send for a few seconds three times the normal current through the motor, so that a 10 and 13 e.h.p. motor respectively will be ample to do the work. But the gear and all the mechanical parts of the machinery must be strong enough to stand the sudden heavy strain, corresponding to 30 and 39 e.h.p. We have given the above figures, merely by way of example, to show the amount of power which may be required for electric tramcars. The figures will have to be modified according to local circumstances. The sooner electrical engineers realise the exact amount of power required, and provide accordingly, the better. We shall then hear no more of failures, and the special systems of the faddists will vanish. There is no difficulty or mystery about electric tramcars. Any trained electrical engineer is competent to produce a thoroughly workable design, and that without becoming indebted to the inventor of any of the special systems. But to ensure success we must leave his hands free, and allow him to design the machinery in accordance with the special requirements of each case.

CORRESPONDENCE.

ELECTRIC TRACTION.

To the Editor of The Electrical Engineer.

Sir,—Mr. Jarman seems to have misunderstood my argument about his double armatures. It is distinctly stated in the report, that one armature is used for propelling the car on the outward, and the other on the return journey. If then the armatures were perfectly cool at the end of each journey, where is the necessity for double armatures, and if both armatures are used at the same time, where is the duplication of the motor? My experience with electromotors for tramway work—which has been with continually running heavily-loaded cars, and not a mere experimental run with a fabulous report thereon—has convinced me that if the car, motor, &c., has been designed by anyone who knows anything about them, the heating of the armature need not be taken into consideration. All armatures, of course, heat a little, but not, if properly designed, to the extent mentioned by Mr. Jarman, which seems deduced more from theory than actual practice.

As to the cost, controversy on this point is useless, as nothing could be stated with any degree of certainty until a prolonged trial of a number of cars has been made; but it is obvious to everyone that the figures quoted are simply ridiculous. Without doubt there is a difference between Mr. Jarman's car and the Stratford electric locomotives, but in my opinion this was the most successful attempt at electric traction by means of accumulators that has taken place. They did *run* satisfactorily, though the cost of maintaining them ultimately proved, as many people had foreseen, quite prohibitory, and the consumption of plates must have been enormous. A similar "system" to Mr. Jarman's was tried on the Brighton and Shoreham tramways, and those who witnessed the miserable exploits of these accumulator cars must have learnt a lesson they will not be likely soon to forget.

With what bluster each so-called new accumulator car system makes a start, but who, beyond those who take the trouble to find out, ever know its ultimate destination? Like the proverbial month of March, the accumulator cars at Stratford came in with the roar of a lion, but they passed from the public view with the meekness of a lamb.

The continued building of accumulator cars with a mere rearrangement of parts will not further electric traction. Anyone worthy of the name of an electrical engineer can put accumulators and motor into a car; the thing is to get an accumulator that will stand the jar and heavy strain thrown on to it by tramway work, and from this it would seem that electric traction by means of accumulators is a problem more for the chemist than the electrical engineer.—Yours, &c.,

F. C. Allsop.

MUNRO AND JAMIESON'S POCKET-BOOK OF ELECTRICAL RULES AND TABLES.

To the Editor of The Electrical Engineer.

Sir,—In your favourable review of this Electrical Engineering Pocket Book (fifth edition) in the *Electrical Engineer* of June 1st, at page 515, you remark, "Magnetic permeability, again, does not find a place, or we have failed to find it." If you will please turn to pages 434 and 435, you will find that both magnetic permeability and susceptibility have received attention, but that we have omitted any precise reference to these terms in the otherwise very full and complete index. This omission will be made good in the next edition.

Since the science of magnetism and electricity in its practical applications are advancing at such a very rapid rate, we are often at a loss to know what new facts should receive a place, and what older ones should be cut out. We are, therefore, very much obliged to you and to other reviewers for any useful hints to guide us in our earnest endeavours to keep the Pocket-Book abreast of the times. If every one of your numerous readers who use the Pocket-Book would kindly jot down in the blank leaves placed at the beginning of the same their ideas upon any particular parts or points with which they may be familiar, or note any new experimental and useful data, and send them on to us through the publishers, or communicate them to your journal, we should feel much indebted to them, and should have much pleasure in thanking them in the next preface. The more critical, severe, and exact our contributors are, the better for the book, and the better we like them.—Yours, &c.,

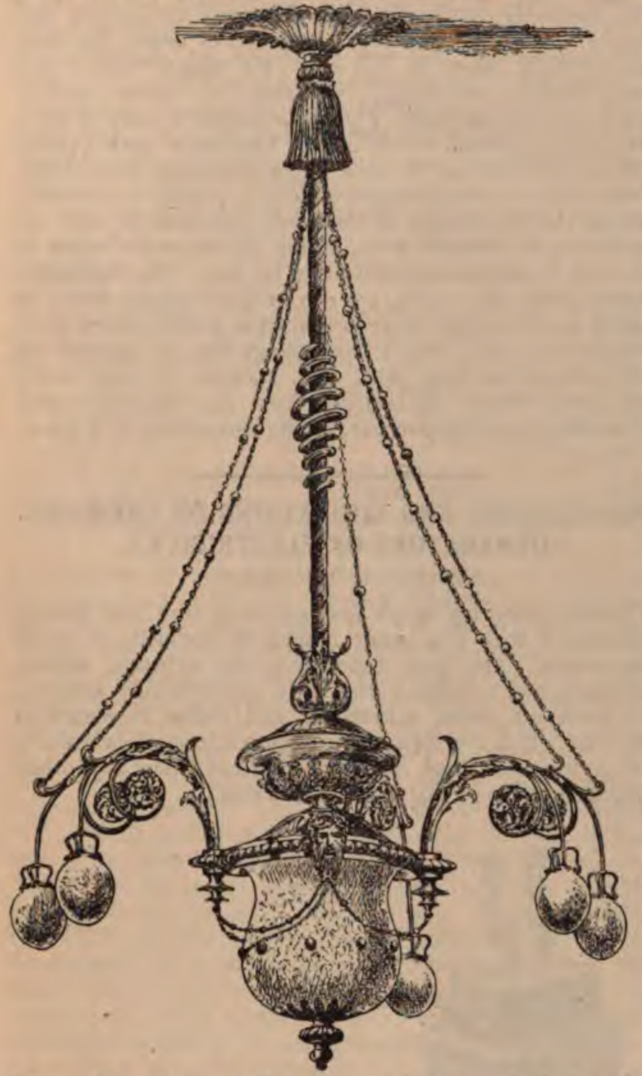
Andrew Jamieson,
Professor of Engineering.

The Glasgow and West of Scotland Technical College,
Glasgow, June 5, 1888.

THE CAFE MONICO.

The Café Monico, Regent-street, which until recently contented itself with the large Siemens' gas lights for its saloons, has now been fitted throughout with the electric light, and considerable taste and care has been exercised in getting the best lighting effect with the most decorative arrangement of the fittings. The marble staircase and the marble entrance saloon, named by Messrs. Monico the Winter Garden, has eight electroliers of ten lamps (16 c.p.) each, of the design which we illustrate herewith, specially designed and made for the Café Monico by Messrs. Faraday and Son, of Berners-street. These are of chased and gilt brass work, with moulded glass globes, studded with ruby dots, and have a very handsome appearance. In the large Renaissance Saloon, lamps of a higher candle power are used, in a long single pendant of the design shown, but with long oval-moulded glass globes, to match the electroliers. The lamps in these are 200 candle power. One of the pendants is suspended from each of the six arches of the saloon, visible outside for some considerable distance, and comparable in light, though not in colour, with neighbouring arc lights, are two large incandescent lamps of 500 candle-power, bare, with small opal shades above them. In the lower saloon are beaten copper and brass electroliers by Messrs. Laing, Wharton and Down. The kitchens and offices are fitted with the ordinary opal shades. The wiring was carried out by Mr. Merry. Machinery for supplying these lamps is situated in the basement, and was supplied and installed by Mr. W. O. Rooper, of Stafford. It consists of a 20-h.p. nominal engine with locomotive boiler made by W. G. Bagnall, of Stafford, which also supplies the

steam for cooking, a Phœnix dynamo by Paterson and Cooper, giving up to 360 amperes at 100 volts; a Blackman



air-propeller, driven off the dynamo shaft, expels the heated air. Provision is made on the switch-board for a spare

dynamo, and another engine and boiler will probably soon be erected to supply a further number of lamps.

CONVERTERS IN AMERICA.*

BY PROF. FORBES.

Having been asked by the Society to add some further account of the manner of working converters in America, I will now briefly comply with that request.

Engines and Dynamos.—It is a mistake to suppose that one or two large engines are more economical than a number of small ones. A large engine working far below its power is very wasteful of steam.

One engine drives one dynamo by belt direct, without countershafting. It is well to have each unit in a station of the same size, so that parts are interchangeable and the attendant has less to think of. The size of unit may be chosen so as to supply, at efficient load, the minimum current required in the 24 hours. One exciter is generally used for four machines in series, with an adjustable resistance. A shunt resistance, largely made up of lamps, may be put on each field for regulation.

Feeders.—These are generally overhead. Waring cable underground (lead-covered) is perfectly successful. Simplex wire is generally used for overhead work. Five or six feeders are often fed by one dynamo. A loss of 2 to 2½ per cent. of potential is generally adopted. Double-bell insulators are used.

Converters.—These are made for 5, 10, 20, 30, and 40 lights. The wiring of a large house is best done with separate circuits for each 40 lights. It is unadvisable to "bank," or group in parallel a number of converters. These converters are very light, and have a smaller quantity of iron than might be thought good. They reduce the potential from 1,000 to 50 volts. The primary and secondary fuses are put inside the converter. The mode of manufacture of these has been described elsewhere. The insulation between the primary and secondary coils is indestructible.

Lamps.—It is found that 50-volt lamps last longer than those with thinner filaments, and are generally used. The potential in the primary is 1,000 volts. No man has ever been killed by a 1,000-volt alternating current. It is well here to mention that you cannot get an arc from the low-potential circuit when an alternating current is used.

Meters.—The Westinghouse Company has made such arrangements as will enable them to charge customers by means of the coulomb-meter.

Station Ampere-Meters.—The same instrument as Edison uses is adopted, but with a bundle of wires sucked into the coil. Both the bundle and the coil form part of an arc of a circle, and the former moves on an axis at the centre of the circle. The force of the current acts against the weight of a counterpoise, and an index indicates the amperes.

Station Voltmeter.—A "three-point converter" reduces the potential either tenfold or twentyfold. A compound-wound "compensator" reduces the measured potential to that at the centre of consumption. The voltmeter is solenoidal in action, and is true only when the speed of engine is quite constant. The wire bundles for these solenoids are ingeniously constructed. A metal cylinder is covered with varnished paper or muslin. Iron wire is wound round the cylinder, sticking to the varnish. The iron wire ring thus formed is cut through and a flat web of iron wire is produced, which can be cut into lengths and rolled into bundles.

Ground-Detector.—Two converters have a lamp on each secondary. The primaries are connected in series to the mains. The intermediate contact is connected to earth. If one of the mains has an earth its lamp goes out. A multiple switch is provided by which each circuit can be tested in turn.

Synchroniser. — To synchronise any two dynamos, secondary wires are led to a switch-board. A wire from one converter is connected to a wire from the other. The two other wires are connected through two lamps. If the connected wires are in the same phase, the lamps go out. A switch is provided by which, as soon as the lamp goes out, the second dynamo is connected to the mains of the first. The dynamos work well in parallel

* Postcript to the "Discussion on Central Station Lighting," from the *Journal* of the Society of Telegraph-Engineers and Electricians.

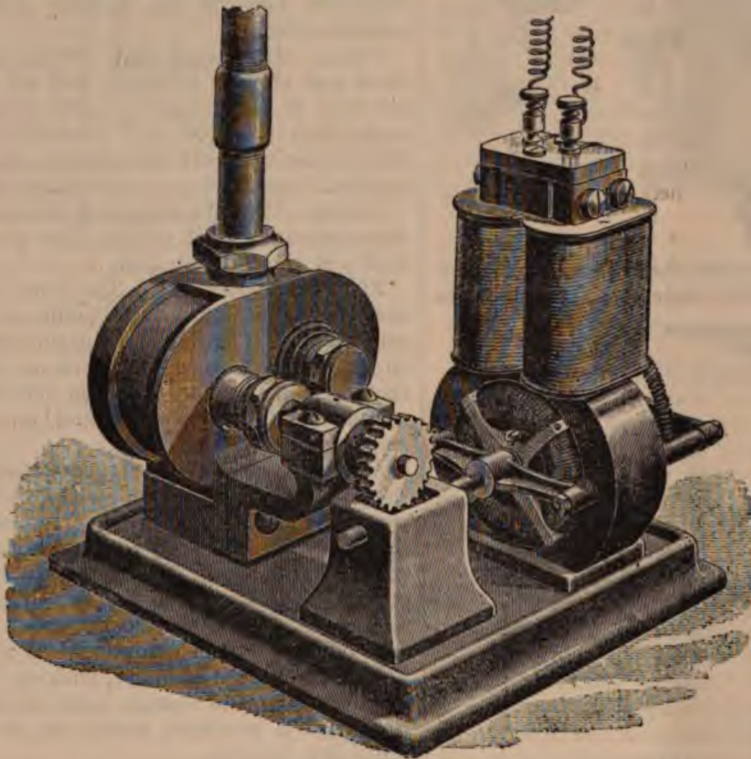
from half to full load. Alleghany station sometimes calls to Pittsburgh, across the river, for assistance in current, and the synchronism is good. Synchronism is found to be quite satisfactory from half to full load, but not below.

Switch-Boards.—A switch-board is generally set up for each dynamo, and for five or six feeders. The conductors going to feeders run up and down; those going to dynamos are horizontal. The dynamo wires are connected with three instruments in a vertical row—an ampere-meter, a converter, and a voltmeter. Each feeder has a vertical row of instruments, a three-point converter, a compensator, and a voltmeter. There are six switches for six feeders in a horizontal row, to switch any feeder into either of two pairs of dynamo conductors. One of these pairs is connected to the switch-board dynamo; the other can be connected, by means of a switch at the side of the board, to the conductors of either of the neighbouring dynamos. An adjustable resistance, with six lamps in series for additional resistance, is at the bottom and middle of the board, and acts as a shunt on the field magnets. Another adjustable resistance is in series with all the field magnets. Another switch connects either of two exciters with the field magnets.

There are some other devices connected with street-lighting and theatre-lighting which I am not at liberty to describe, owing to the English patents being not yet completed.

AN ELECTRIC PUMP.

In large mansions where no water pressure is available hand-pumps are often used to pump the water to a cistern high enough to supply the upper storeys. In many cases steam or gas engines are employed, but for these a considerable amount of care and supervision is required in pumping. In town residences, hotels, and flats of great height, where the town pressure is not sufficient, additional pumps are often required. We illustrate a new pump for this purpose actuated by an electric motor, invented by A. E. Hall, of Plainfield, New Jersey, U.S. The machine is very neat and compact, and has a great advantage where a source of electricity is available, that no attention is required to be given to it, except an occasional oiling of the cups. It occupies about 24 square inches of space, and is practically silent in its operation. The wires are led to a float in the cistern at the top of the house, which plays the part of regulator and attendant; the supply stopping when the float rises, and continuing as long as there is insufficient water in the tank. It is therefore perfectly automatic, and the parts are so few and simple that it is not likely to get out of order; the wear is so slight that it will last for many years; and one further advantage is, that a much smaller cistern can be used than where the engine is only at work for a certain period of the day. The use of such a pump will no doubt extend at once where electricity is available, either from a central station or from a private installation, and, as the distribution of electricity proceeds, we shall no doubt find the electric pump filling an important place in the field to which electricity can be put. The Hollenden House Hotel, New York, has one of these pumps fitted to supply its two upper storeys, and it is working with great satisfaction. The No. 1 size pump has a capacity of 150 gallons per hour, with 25ft. suction, to raise water 50ft. above itself It is driven from the connection with an incandescent lamp-socket, taking one-eighth of a horse-power.



New Electric Pump.

POSSIBILITIES AND LIMITATIONS OF CHEMICAL GENERATORS OF ELECTRICITY.*

BY FRANCIS B. CROCKER.

Electro-chemistry seems less generally and less clearly understood than any other branch of electricity of equal importance. The facts concerning the dynamo, motor, telegraph, and telephone are widely and definitely known; but there are ideas, statements, and claims in regard to batteries which are further from the truth, more prevalent, and go longer without being contradicted, than any other collection of errors that I can call to mind.

Primary batteries have not received the attention in this country that they have abroad, particularly in England, where the successful or unsuccessful attempt to float a new primary battery company is a matter of almost weekly occurrence. Nevertheless the subject is a sufficiently important one, and the false ideas of which I have spoken have spread so far beyond the quacks, to whom such ideas are usually confined, that the subject deserves more study than it usually receives, particularly from the scientific standpoint.

Electromotive Force.—The electromotive force which a given battery or combination of materials will develop is the first and most important question in electro-chemistry. Of course, the best and surest way to arrive at this E.M.F.

*Read before the American Institute of Electrical Engineers, May 16.

is to determine it by actual experiment with a voltmeter, or, still better, by comparison with a standard cell. There are, however, many times when the materials or instruments are not at hand, and a calculation or predetermination of the E.M.F. is very convenient.

The formula for calculating the E.M.F. is obtained by assuming that the electrical energy of the given chemical combination is equal to the heat energy which the same combination is capable of producing, or $EC = 4 \cdot 16\, C a\, H$ That is, volts multiplied by coulombs is equal to the coulombs multiplied by the electro-chemical equivalent—*i.e.*, the weight of material required per coulomb and that by the heat produced by one gramme of the material. Cancelling the C in both members, we have $E = 4 \cdot 16\, a\, H$, in which E is the E.M.F. in volts, a is the electro-chemical equivalent (grammes per coulomb), and H is the number of heat units (gramme-degrees Cent.) produced per gramme of material by the given chemical combination. The values of a and H are given for most materials in electrical and chemical books of reference, and the calculation is a very simple one. Nevertheless, this formula and the principle involved in it are not generally understood, and are very seldom used. The equation deduced above is that ordinarily given; but what I have found to be a more convenient form of it is obtained by assuming that $E = H$, giving a its value for hydrogen (·00001035). Solving with respect to H, we have $H = 23300$, which means that 23,300 is the number of heat units per equivalent corresponding to one volt, and all that is necessary to find the E.M.F. of any given chemical combination is to divide the number of heat units per equivalent (which is the form they are almost always given in) by 23,300, and the quotient is the E.M.F. in volts. For example, to obtain the E.M.F. which zinc and free chlorine will develop, divide 48,600 (which is the number of heat units produced by the combination of one equivalent of zinc with one of chlorine, as given by Thomson) by 23,300, and the result, 2·09, is certainly very close to 2·11, the actual value obtained by experiment. In the same way the E.M.F. of other combinations of materials may be predetermined, but it should always be borne in mind that the heat of combination corresponding to one *equivalent* of the material should be taken, and not necessarily that corresponding to one atom, as, for example, in the case of zinc, the heat per atom (65 grammes) is 97,200 which has to be divided by 2 to reduce it to one equivalent because zinc is a dyad, and takes two atoms of chlorine, which is a monad. In the case of monad metals like sodium, potassium, and silver the figures may be taken just as they given in the tables. Mistakes very frequently arise in this way; in fact, I do not think I ever saw a table of electro-chemical equivalents in which this point was correctly introduced in every case.

In order to test the practicability and accuracy of calculating E.M.F., as well as to obtain reliable results and full data for their own value, I determined the E.M.F. given by thirteen of the most important metals in combination with free chlorine, bromine and iodine, and the results are given in Tables A, B, and C respectively. In Table D, I have averaged these results and placed them side by side with the results obtained by calculation. The agreement between the two sets of figures is not perfect by any means; but when it is remembered how the E.M.F. of a cell will change one or two-tenths of a volt on apparently the slightest provocation, I think the figures are strikingly close, more so than I expected to find them. In more than half of the cases the difference is less than one-tenth of a volt, and the average difference is only slightly more than that. There has been no warping or coaxing of the figures to secure uniformity. The results are given just as they came. If figures were picked out from the different observations, it would be possible to obtain almost perfect agreement between the calculated and determined, as one may see by looking over the tables.

In regard to the experimental results, as given in tables A, B, and C, I may state that all the metals and salts used were chemically pure, with the exception of the metals magnesium and aluminium, and these were of a very good quality. Pure carbon plates were used for the negative plate, but platinum was also tried and gave substantially the same results. The E.M.F. was measured by a Thomson reflecting galvanometer (by Elliott), using two independent standard Daniell cells. One fact which strikes one in looking over the tables A, B, and C, is that the E.M.F. is not very greatly affected by the solution; a certain metal gives about the same result in one chloride as in another, and the same is true of the bromides and iodides. In Table E, I have given the E.M.F. obtained by substituting different metals for the zinc in a Daniell's cell, but these results being from only one series of observations are probably not so reliable as those in the preceding tables.

In the remaining table I have collected in condensed form the principal facts in regard to batteries in which zinc is used as the electro-positive material with the most important electro-negative or depolarising materials. The facts in regard to metallic zinc, which hold good in all cases in which it is used (no matter what the other material is), are given on a horizontal line with zinc. Below this, the facts in regard to each particular combination are given opposite the depolariser. For example, the data of a zinc and chlorine battery are given on a horizontal line with chlorine, of a zinc and nitric acid (Bunsen) battery, on a line with nitric acid.

For convenience the table is divided into two parts; the left-hand side contains the purely scientific data, and the right-hand portion contains the practical facts.

In the first column of the first part are given the chemical symbols reduced to a common basis, any one of the expressions being chemically equivalent to any other. For example, one-half atom of zinc ($\frac{1}{2}$ Zn) requires one atom of chlorine (Cl), or one-half atom of oxygen ($\frac{1}{2}O$), or one-third molecule of chromic acid ($\frac{1}{3}Cr_2O_3$), or one-sixth of the mixture of one molecule of potassium bichromate and seven molecules of sulphuric acid ($\frac{1}{6}\,[K_2Cr_2O_7 + 7H_2SO_4]$), and so on.

In the second column is given the chemical equivalents, which are simply the proportions by weight required of the different materials. That is, when we use 32·5 grammes (hydrogen being assumed as one gramme), we require 35·5 grammes of chlorine, or 33·4 grammes of chromic acid, and so on.

The third column contains the electro-chemical equivalents, which are really exactly the same and directly proportional to the combining weights in the previous column, but are reduced to an electric basis of so many milligrammes per coulomb. To convert these figures into grammes per ampere hour simply multiply by 3·6.

In the first column of the second part of the table is given the E.M.F. of each combination, all of which, with the exception of oxygen, sulphur, and water, are determined by experiment, most of them being well-known and accepted values. In the case of oxygen, sulphur, and water, the E.M.F. is calculated as explained above, and are merely given for comparison. No actual battery corresponding to these materials exists.

In the second column on the right-hand side is given the number of pounds of zinc required per h.p. hour in the case of each combination. For example, a zinc and copper sulphate (Daniell) battery requires 1·86 pounds of zinc per h.p. hour of electrical energy produced.

In the next column I give the weight of depolarizer required per h.p. hour in the case of each combination. For example, a battery requires 5·05 pounds of the mixture of three parts of potassium bichromate, and seven parts of sulphuric acid, which is about the ordinary strong bichromate solution for porous cell batteries. Of course the water required for the solution is not considered here, or in any of the other figures of the tables, because it costs nothing and serves merely as a medium of electrical action; but if the total weight of solution is desired, the weight of water must be added.

The weight of the different materials consumed per ampere-hour is given in the next column. These figures are obtained directly from the electro-chemical equivalents in the third column by dividing by 125; in fact, they are simply the electro-chemical equivalents in pounds per ampere-hour.

It should always be carefully noted that the weight consumed per ampere-hour is that required in *each cell* in *series*, whereas in the case of horse-power hours the weight given

in the table is the total weight used, no matter how many cells there are or how they are arranged.

In the next to the last column is given the wholesale cost per pound of the different materials. These prices are of course very difficult to fix, because they depend upon the market and vary greatly upon the quantities bought; but the prices I have here are very low, and ordinary consumers would have to pay twice as much in most cases; they give, however, some idea of costs.

In the last column, I have given the cost of both materials, zinc and depolariser, added together. I have not here considered the values of the products, because it is very difficult to estimate the cost of collecting and utilising residues. In the case of silver chloride, the silver resulting from the action would, of course, be worth a large portion of the cost of the original chloride.

One of the interesting points which this table shows is the total weight required per horse-power hour. For example, ·95 pound of zinc and 1·04 pounds of chlorine, making a total of almost exactly 2 pounds, would produce 1 h.p. of current for one hour if all of the chemical energy could be converted into electric energy.

This brings up the question of how large a percentage of the chemical energy can be utilised, or, in other words, the efficiency of chemical generators. This efficiency is higher, I think, than it is generally supposed to be. I have no exact figures upon this point, but I have tested several times the weight of zinc consumed compared with the theoretical amount, and I have found that even in a plunge battery, where the bichromate solution was directly in contact with the zinc and the opportunity for local action was a maximum, that the zinc efficiency was as high as 75 per cent., and in one case 80 per cent. In a porous cell battery with amalgamated zinc, where there was little or no cause for local action, I believe the zinc efficiency would be as high as 90 per cent., and I should not be surprised to find it as high as 96 or 97 per cent.

The efficiency of the depolariser is generally lower than that of the zinc, because there is generally a good deal of chemical energy left in the solution after it is too weak for satisfactory work. The efficiency of the bichromate solution in the plunge battery I have just referred to was only about 45 per cent. of the total theoretical power. But this is very low, because the solution has to be weak in acid on account of being used in contact with the zinc. In the case of a copper sulphate battery, where the crystals of sulphate are often almost entirely used up, I think the efficiency would be as high as 80 or 90 per cent.

The efficiency I speak of here is simply the *chemical* efficiency in the battery; the fall of potential in the battery due to its internal resistance compared to the external is another loss which has to be added to the chemical loss in determining the total efficiency. The possibilities of chemical generators are therefore almost infinite, since it requires theoretically a total of only two pounds of zinc and chlorine, and two pounds of zinc and chromic acid per horse-power hour, and since the efficiency of batteries can easily be made as high as 75 per cent., it follows that less than three pounds of material is actually required per horse-power hour; but unfortunately the water for the solution, the containing vessel, electrodes, &c., are so heavy that the total weight is very many times greater. The possible and the actual battery are thus very far apart. If we use metals of higher chemical affinity and E.M.F. than zinc, the theoretical weight of material required is even less; only one pound total of chlorine and magnesium are required per horse-power hour, with metallic sodium and free chlorine having a calculated E.M.F. of 4 volts it would only take about ·8 pound per horse-power.

The easiest and best solution of the problem, however, does not seem to be the use of more powerful metals than zinc. The latter is powerful enough; it only takes, as we have seen, about one pound of it per h.p. hour with nitric acid, chromic acid or bichromate solution, and less than two pounds with copper sulphate. The opportunity for improvement seems to lie more in the direction of perfecting the general form of batteries. The *apparatus* is at fault, not the *chemical action*. Moreover, zinc is about as high on the electro-positive scale as it is safe to go, so long

TABLE A.—E.M.F. produced by different metals in combinations with free chlorine in solutions of—

—	Magnesium Chloride.	Zinc Chloride.	Zinc Chloride.	Zinc Chloride.	Hydrochloric Acid.	Common Salt.	Average.
Magnesium..	2·83–2·65	2·65			3·2–3·15	2·85	3·1
Zinc	2	2·20	2·13	2·11	2·20	2 18	2·11
Cadmium ...		1·94		1·86	1·98	1·93	1·9
Aluminium .	1·75	2·04	1·88		2·02	1·98	2·
Iron		1·60	1·56	1·5	1·67	1·68	1·6
Cobalt		1 43	1·43	1·41	1·50	1·45	1·43
Nickel		1·33		1·27	1·40	1·33	1·33
Tin	1·50	1 70	1·6	1·57	1·68	1·66	1·61
Lead		1·63	1·62	1·60	1·68	1·65	1·63
Copper		1 31	1·30	1·29	1·37	1·34	1·32
Silver		1·11	1 12	1·13	1·15	1·10	1·11
Antimony...		1·20	1·23	1·25	1·25	1·08	1·22
Bismuth ...		1·29	1·25	1·20	1·27	1·19	1·21

TABLE B.—E.M.F. of different metals with free bromine in solutions of

—	Magnes. Bromide	Nickel Bromide.	Potass. Bromide.	Hydro-Bromic. Acid.	Magnes. Bromide weak.	Average.
Magnesium ..	2·55	2·45	2·51	2·7	2·57	2·56
Zinc	1·84	1·78	1·82	1·79	1·85	1·79
Cadmium ...	1·6	1·54	1·62	1·57	1·61	1·58
Aluminium ..	1·5	1·46	1·47	1·46	1·6	1·53
Iron	1·22	1·25	1·31	1·26	1·33	1·3
Cobalt	1·1	1·02	1·05	1·06	1·13	1·05
Nickel	·8	·85–·8	·8	·87	·94	·85
Tin	1·12	1·31	1·3	1·25	1 27	1·3
Lead	1·4	1·27	1·33	1·28	—	1·33
Copper	1·05	·96	1·01	·99	1·03	1·02
Silver	·97	·94	·97	·95	·93	·95
Antimony ...	·99	·73	·71	·87	·97	·8
Bismuth	·92	·9	·96	·88	·92	·92

TABLE C.—E.M.F. of different metals with free iodine in solutions of—

—	Magnes. Iodide.	Zinc Iodide.	Potass. Iodide.	Average.
Magnesium	2·02		2·00	2·01
Zinc	1·35	1·23	1 29	1·25
Cadmium	1·12	1·12	1·13	1·12
Aluminium	·95	83	·87	·88
Iron	·69	·6	·74	·68
Cobalt	·6	42	·5	·51
Nickel		·35	·37	·36
Tin		·72	·69	·71
Lead		·82	·85	·83
Copper	·63	·67	·62	·64
Silver	·65	·67	·64	·65
Antimony	·41	·47	·46	·44
Bismuth	·39	·46	·42	·43

TABLE D.—Comparison of the E.M.F. Calculated from the heat of combination and the E.M.F. determined by experiment.

Metals.	Combining with Chlorine Calc.	Determ.	Bromine Calc.	Determ.	Iodine Calc.	Determ.
Magnesium..	3·24	3·1				
Zinc	2·09	2·11	1·68	1·79	1·05	1·25
Cadmium ...	2·	1·9	1·58	1·58	·97	1·12
Aluminium..	2·3	2·	1 7	1·53	1·00	·88
Iron	1·75	1·6	1·5	1·3	·85	·68
Cobalt	1·64	1·43				
Nickel	1·57	1 33				
Tin	1·71	1·61	1·5	1·3		
Lead	1·76	1·63	1·38	1·33	·85	·83
Copper	1·4	1·32	1·07	1·02	·69	·64
Silver	1·25	1·11	·95	·95	·59	·65
Antimony ...	1·3	1·22				
Bismuth	1·3	1·21				

TABLE E.—E.M.F. produced by different metals substituted for zinc in a Daniell's cell.

Metals.	Volts.	Metals.	Volts.
Zinc	1·08	Lead	·58
Cadmium	·79	Copper	·07
Aluminium......................	·65	Silver	·02
Iron	·64	Antimony	·09
Cobalt......................	·40	Bismuth......................	·17
Nickel......................	·1		

Symbols. — Chemical expressions reduced to a common basis.	Chemical equivalents. — Proportions in which materials combine.	Electro chemical equivalent. — Weight of material consumed per amp. sec.	Name of materials.	Electromotive force produced.	Weight of zinc consumed per h.p. hour.	Weight of depolariser consumed per h.p. hour	Weight of materials consumed per ampere hour in each cell.	Cost of materials wholesale.	Total cost of both positive & negative materials per h.p. hour.
	H=1.	Milligrams per coulomb.		Volts.	Pounds.	Pounds.	Pounds.	Per pound.	
$\frac{1}{2}$ Zn	32·5	·337	Metallic zinc				·C0ż7	\$.07	
+			used with following electronegative or depolarising elements :						
I	127·	1·314	Free iodine	1·2	1·67	6·53	·0105	3.60	\$22.97
Br	80·	828	Free bromine	1·79	1·12	2·76	·0066	.38	1.12
Cl	35·5	·367	Free chlorine	2·11	·95	1·04	·0029		
$\frac{1}{2}$ O	8·	·083	Free oxygen*	1·9	1·5	·26	·00066		
$\frac{1}{2}$ S	16·	·166	Free sulphur*	·95	2·1	1·03	·0013	.02	.17
			CHEMICAL COMPOUNDS.						
$\frac{1}{2}$ H_2O	9·	·093	Water*	·5	4·	1·1	·00074		
HNO_3	63·	·652	Nitric Acid	1·9	1·05	2·04	·0052	.06	.20
$\frac{1}{3}$ CrO_3	33·4	·346	Chromic Acid	2·	1·	1·03	·0027	.20	.28
$\frac{1}{2}$ $CuSO_4$	79·7	·826	Copper sulphate (anhyd.)	1·079	1·86	4·55	·0065		
$\frac{1}{2}$ $CuSO_4 \cdot 5H_2O$	124·7	1·29	Copper sulphate (crystals)	1·079	1·86	7·13	·0102	.06	.56
$\frac{1}{2}$ Fe_2Cl_6	162·5	1·683	Iron perchloride	1·55	1·3	6·5	·0133	.10	.74
$AgCl$	143·5	1·487	Silver chloride	1·06	1·89	8·32	·0118	16.00	133.25
$\frac{1}{2}$ Hg_2SO_4	248·	2·57	Mercury sulphate	1·42	1·41	10·7	·0204	.50	5·45
			MIXTURES.					Mixture per lb.	
$\frac{1}{6}\left\{\begin{matrix}K_2Cr_2O_7\\7H_2SO_4\end{matrix}\right\}$	163·5	1·694	Potass. brichrom, 3 parts; Sulphuric acid, 7 parts	2·	1·	5·03	·0133	.04	.27
$\frac{1}{3}\left\{\begin{matrix}K_2Cr_2O_7\\4H_2SO_4\end{matrix}\right\}$	229·	2·37	Potass. bichrom., 3 parts; Sulphuric acid, 4 parts	2·	1·	7·04	·0186	.05	.42

* Calculated.

as water is present. Even in the case of zinc, its affinity for oxygen is greater than that of hydrogen ; it is therefore only by tolerance, so to speak, that zinc remains passive in the presence of water. If it is not properly amalgamated, or if the solution is too strong, local action does occur. If in place of zinc we use any more electro-positive metal, these troubles are aggravated. With magnesium, for example, there are only very few solutions in which it will stand without great local action. Metals of still higher power, such as sodium, cannot be used at all in the presence of water. Jablochkoff has, I believe, made cells in which sodium is used with damp cloth, but this can hardly be considered as water.

The proper way to use metals of great chemical energy would seem to be with liquids which do not contain any oxygen, but unfortunately such solutions are not generally good conductors. Another possible plan is to employ a fused electrolyte, but this involves the serious difficulty of maintaining it in the fused state.

So far as I can see, zinc is a very satisfactory positive material for batteries. After all, it is cheaper than any other metal except iron. It is a sufficiently good conductor and less dirty and liable to corrosion than almost any other metal ; it is also, as I have just shown, about as high on the electro-positive list as it safe to go.

The electro-negative materials, on the other hand, leave far more to desired. They are generally very expensive, very troublesome to handle, and introduce that quality of simple dirtiness, to which no other name can be applied, and which is really the most serious objection to batteries. The electro-negatives will, however, do the work, and as we have seen it actually requires very little weight to give a great deal of power, if the materials could only be used in a more perfect manner than at present. That seems to be the thing to hope for. Another serious difficulty with batteries is their high internal resistance. A dynamo can easily be made to give 100 volts with a thousandth or a few ten thousandths of an ohm internal resistance, hence their great output ; but a battery capable of giving 100 volts with only one thousandth of an ohm internal resistance would probably fill this house.

In this connection it will be interesting to consider how many cells of ordinary gravity battery are required to give one horse-power of current. Each cell will give one volt, and not more than half an ampere under normal conditions ; hence each cell furnishes half a watt, or about 1,500 cells to the horse-power ! These cells would, however, give that power for a long time ; but the fact remains that that very large number is required to produce the power which a dynamo not much larger than one's hat will generate.

In conclusion, I would say that I am by no means a sceptic in regard to chemical generators of electricity. The possibilities are very, very great, as I have shown ; but these possibilities do not seem to have been brought to reality in a very perfect manner as yet. But batteries, even in the imperfect state in which they exist to-day, have their useful and legitimate function. A Leclanché cell is exceedingly well adapted to ringing electric bells intermittently and to telephone work, and gravity batteries have long done good service for telegraphic purposes.

But when it comes to developing any considerable amount of actual power, then the limitations become apparent. When we remember that battery electricity will certainly cost in practice 50 cents per horse-power hour, since the materials alone cost 25 cents, and that dynamo electricity only costs two cents per horse-power hour, the claims of some primary battery electric lighting promoters show up in their true light. As a luxury, of course, it makes very little difference what it costs, but even then people soon tire of paying very high prices for that kind of a luxury. For small electric lighting, and small power in special cases, batteries are useful, particularly where no other source of current is available. A physician or dentist, to whom a horse-power hour may be worth hundreds of dollars, could almost afford to use a chloride of silver battery and throw away the silver.

A Simple Electroscope.—In examining the dry film of collodion, Prof. Jouravski has found that it can be electrified negatively with great facility. It is sufficient to rub it slightly between the fingers. As it is extremely thin, it will approach objects electrified positively, and repelled from those negatively electrified. In this way, with a strip of collodion film, the polarity of electrified objects can be readily verified. To prepare the film the collodion is poured on a glass of water, and after the ether is evaporated the film which remains can be easily removed and cut into long, straight strips, each of which constitutes a perfect electroscope. These bands should be kept in an obscure place. The author mentions these facts with the idea that such a simple and ready electroscope may be very useful to physicists.—*Russian Physico-Chemical Journal.*

PHYSICAL SOCIETY—May 26.

Mr. Shelford Bidwell, F.R.S., Vice-President, in the chair.

Mr. S. O. Roberts was elected a member of the Society.

The following communications were read :—

"Note on the Governing of Electromotors," by Profs. W. E. Ayrton and J. Perry. In a paper read before the Society of Telegraph-Engineers, in 1882, the authors deduced the conditions of self-regulation of electromotors for varying load when supplied either at constant potential or with constant current. The conditions involved "differential winding," *i.e.*, the use of a shunt motor with series demagnetising coils. With this arrangement fairly good regulation has been obtained, but owing to want of economy the methods have not been developed further. Since then another arrangement, in which a simple shunt motor is used and a few accumulators placed in series with the armature, has been devised for working in a constant current system. By means of a suitable switch the accumulators can be charged when the motor is at rest. On the assumption that the E.M.F. of motors is given by $E = n(p + tZ)$ where n = speed, Z = number of turns on magnets and p and t are constants, it is shown that the speed at which a motor will govern is given by $\frac{n = z + a + a^1}{t}$, and the constant current $\frac{C = e - n\,p}{a + a^1}$, where z_1 and a are the resistances of the shunt and armature respectively, and e and a^1 the E.M.F. and resistance of the accumulators Since a and a^1 may be small, and $n\,p$ not large, the value of e need not be great to give a considerable value for C, and thus only a small number of accumulators will be required.

"On the formulæ of Bernoulli and Hæcker for the Lifting-power of Magnets," by Prof. S. P. Thompson, D.Sc., read by Prof. Perry. The formulæ referred to are $P \propto \sqrt[3]{W^2}$ and $P = a \sqrt[3]{W^2}$ respectively, where P = lifting power, W = mass of magnet, and a a constant depending on the material and shape of the magnet. These formulæ, the author shows, are equivalent to saying that the lifting power of magnets in which the magnetic induction B has been carried to an equal degree, is proportional to the polar surface, and that Hæcker's coefficient a is proportional to B^2 through the surface. Assuming the induction uniform over the surface, it is shown that $P = \frac{1}{8T} B^2 A$, where A = area of surface, and this gives a very convenient method of determining B from measurements made upon the pull exerted at a given polar surface. If P be measured in kilos, and A in square cms., the formula for B becomes $B = 5{,}000\sqrt{\frac{P}{A}}$, and if the measurements be made in pounds and inches the constant becomes 1,317. It will be readily seen that the greater power of small magnets in proportion to weight does not require for its explanation the sometimes alleged fact that small pieces of steel can be more highly magnetised than large ones, for if B be the same, the lifting power will be proportional to the polar surface, and not to weight, and hence must necessarily be greater relatively to weight in small magnets. In the case of electromagnets for inductions between 6,000 and 16,000, between which the permeability, μ, is approximately given by $\mu = \frac{16{,}000 - B}{3{\cdot}2}$ the lifting-power is shown to be $P = A\left(\frac{3{\cdot}2\,S\,i}{S\,i + 2{\cdot}56l}\right)^2$ Where P is in kilos, A in square centimetres, $S\,i$ = ampere turns and l = mean length of the magnetic circuit.

"Experiments on Electrolysis," Part II., Irreciprocal Conduction,* by Mr. W. W. Haldane Gee, B.Sc., and Mr. H. Holden, B.Sc. An abstract was read by the Secretary. The authors have observed when strong sulphuric acid is used as an electrolyte, the electrodes being of platinum, that the decomposition nearly ceases if, by decreasing the resistance in circuit, it is attempted to increase the current beyond a certain maximum. When this condition (called the insulating condition) is arrived at, reversing the current immediately restores the conductivity. Experiment shows that the current density is an important factor, and that the composition, viscosity, and temperature of the electrolyte, as well as the previous history of the electrodes have considerable influence on the current density at which the insulating condition occurs. The seat of the insulating layer is found to be at the anode, and the authors believe it due to very concentrated acid formed around the electrode, whose specific resistance is very high. Experiments were also made with carbon and gold electrodes ; and phosphoric acid, caustic potash, soap, and sodium benzoate were used as electrolytes, the result of which seem compatible with the concentration hypothesis above stated. The paper contains an historical and critical account of allied phenomena, and tables expressing the numerical results obtained by the authors are given.

* Irreciprocal conduction is said to occur if a reversal of the direction of a current causes any change in its magnitude.

THE ELECTRIC LIGHTING MOVEMENT IN BRADFORD.

LOCAL GOVERNMENT INQUIRY.

On Thursday, May 31st, Major Tulloch, R.E., one of the inspectors of the Local Government Board, held an inquiry at the Town Hall, Bradford, in respect to the application of the Corporation for sanction to borrow £20,000 for the purposes of the proposed electric lighting installation in the borough. There were only about half a dozen persons present in addition to the inspector. Alderman Frederick Priestman, chairman of the Gas Committee, and the Town Clerk (Mr. McGowen) represented the Corporation; and Mr. J. N. Shoolbred, electrical engineer to the Corporation, was also present.

The **Town Clerk,** in laying the case of the Corporation before the inspector, stated that some time since the Corporation obtained a confirmatory Act of Parliament which empowered them to supply electricity for lighting purposes and for motive power. By that Act two years' grace was given to the Corporation, within which time they were to do something towards putting into operation the powers granted, subject to the condition that if the Corporation did not move within that period, and any company wished to take up the project, the powers granted to the Corporation should not stand in the way. Before the two years expired, however, the Corporation introduced a Bill into Parliament containing clauses seeking to make their electric lighting powers permanent. The Board of Trade, after considering that portion of the Bill, came to the conclusion that it would be undesirable to give to the Corporation such powers in a permanent form, but gave them an assurance that if any other persons came to the borough with any project the Corporation should be duly considered, and the powers granted to them should remain in their hands unless there had been unreasonable and wilful default on their part. About that time, as the inspector would be aware, the subject of electric lighting was not so far advanced as it had since become, and it was thought best to let the matter remain in abeyance for awhile, pending such improvements as might be made. Some time afterwards a company came to the Corporation and asked for permission to carry cables over the streets. This seemed to the Corporation a most objectionable mode of procedure, considering the weight of the cables and consequent danger to the public; and as other persons, including the Post Office authorities, were required to carry wires underground in the busy parts of the town, the Corporation refused the application. To some people it might have seemed ungracious on the part of the Corporation to refuse liberty to the company to use their electric powers, while at the same time the Corporation had similar powers but neglected to carry them into effect. The Gas Committee thought it well to bring the subject up for discussion in the Council, and, it being found that there was likely to be a considerable demand for the electric light, it was, after full inquiry and consideration of the subject in all its bearings, determined that the Corporation should make a start. No one, however, yet knew sufficient of electric lighting to justify the setting up of a complete system for the whole borough, and it was thought that the most judicious mode of proceeding would be for the Corporation to select a central portion of the town and to have a limited installation put down until it was seen how far the project was successful. Plans were therefore prepared by Mr. Shoolbred, acting for the Corporation, and it was resolved to seek powers to borrow the necessary money ; and the Council having made application to the Local Government Board for that purpose, as directed by the Act of 1883, the result was the inquiry now being held. As the inspector well knew, the Corporation was required to give the utmost publicity to everything they did, and such had been the case in the present instance. So far as could be ascertained, the scheme seemed to meet with very general approval, and the absence of opposition was a strong testimony in favour of this view. It should be stated that the trade of the town was of a peculiar character, and the Corporation were told by the merchants that the electric light would be a great convenience to them, as facilitating the matching of tissues of the various textile fabrics produced in the town, as also in showing off the various shades of colour. It remained for the inspector to say whether he felt justified in recommending that sanction be given for the Corporation to borrow the amount for which application had been made. It was at first thought that £20,000 would be sufficient to meet the demands, but when tenders had been received for the necessary works, it was found that nearly the whole of that sum would be absorbed, and the Corporation requested to be allowed to amend their application so as to include an additional £5,000. In the year 1871 the Corporation bought up the undertaking of an old gas company, and it might perhaps be thought that in seeking now to supply electricity they were cutting their own throats ; but being satisfied that there was a demand for the electric light, they wished to be able to supply it themselves, and so maintain the exclusive control of the streets, as they were apprehensive that if any trading company were to get a foothold in the town the difficulties of the Corporation would be very much enhanced. It was most desirable that only one authority should deal with the streets, and every arrangement would be made to secure economy in carrying out the project.

Alderman F. Priestman added his confirmation to the Town Clerk's statement, and explained the desirability of having the works proceeded with as soon as practicable. Considering the substantial character of the plant to be laid down, he urged that the term of the loan should be as long as possible.

The **Town Clerk** proposed to call Mr. Shoolbred, the Corporation's electrical engineer ; but the **Inspector** stated that the engineer had already supplied him with the fullest particulars, and that no further information was really needed on his part, adding that there was nothing in relation to the scheme generally, or arising out of the inquiry, to which he saw the least objection. The Inspector remarked that the best course for the Corporation to adopt would be to address to the Local Government Board a supplementary application for the additional £5,000 required. It was highly desirable that an inquiry should have been held, as the subject was new both to the Corporation and the Department. Indeed, he believed the Bradford Corporation were the first municipal authority to take action in the manner they proposed.

On the motion of **Alderman Priestman,** seconded by **Mr. Joseph Edmondson,** a vote of thanks was passed to the inspector for his courtesy in conducting the inquiry, and **Major Tulloch** having responded, the proceedings closed.

COMPANIES' MEETINGS.

SWAN UNITED ELECTRIC LIGHT COMPANY.

An extraordinary general meeting of the Swan United Electric Light Company, Limited, was held on Tuesday at the Cannon-street Hotel, for the purpose of considering and, if deemed desirable, approving of an agreement dated May 5, 1888, and made between the Company of the one part and the Compagnie Continentale Edison de Paris of the other part, and of authorising the Directors to do all acts necessary for carrying such agreement into effect. Mr. James Staats Forbes occupied the chair.

The Chairman: Gentlemen, this is a very important meeting for the shareholders of this Company. I will try to be as brief as possible, but in view of the great importance and perplexity of the matter I am afraid I shall not be very short, because I think it necessary you should understand what you are about to do. What we are about to do is, in fact, to imitate abroad what we have done with great advantage to ourselves at home. You know the history of the United Company, in which you have a very large interest; you were in litigation with the Edison Company as to the respective patents of Mr. Swan and Mr. Edison in Great Britain and Ireland. We took very strong views of the priority and value of the Swan patents. They took the same views as to priority and value of the Edison patents, and we were fast verging upon what might possibly have been ruin to both companies—litigation to the death—to settle which was the governing patent, and whether there was any patent at all. In that state of things, happily for us, prudent counsels prevailed. The two companies were put together on the theory of making the best of what had been done, assuming bona fides on both sides, in building up the united business, which should have the advantage of preventing litigation, the raising of very delicate questions as to the value of priority of both sets of patents, by uniting them both for the purpose of defence against the common enemy, the infringer. Now, that is what we did in England; it was rather more easy here for the reason that the Edison Company had got the entire control of the Edison patents in Great Britain and the Swan Company had got the entire control of the Swan patents. There were no other interests. But abroad it is a little different. There, as here, Mr. Swan and Mr. Edison are face to face; as here, the one accuses the other of infringement. The Swan Company abroad are in the same position as they were here—that is to say, wherever patents have been registered they are the sole possessors. That is not quite the case with the Edison; they seem to have been handed over originally to one or more parties by Mr. Edison, and as we have to deal with things as we find them, it is not much good going into their history. We find, however, that the Edison Company, of Paris, with whom we are dealing, has not the same absolute power over the patents for the whole of Europe that the Swan Company has, or that the Edison Company had in Great Britain. You will see at once that led to rather more difficulty in negotiation. There have been more "Richmonds in the field." The Swan Company for the last two years has been not indisposed, in view of legal proceedings on patents, to come to an agreement with the Edison Company abroad. But we were face to face with considerable internal difficulties—in fact, to know who we were to negotiate with, and how one district was to be protected in which one set of people had the command, and another in which another set of people had the command. That has taken a great deal of time, and we have come to the conviction that it was wise to do abroad what it was wise to do here, for the very same reasons. While conflicts were going on, there was great uncertainty and cost in fighting. In the second place, the fact of there being litigation has a depressing effect on the spread of the invention. People do not like to go into installations and run risks of being served with notices from time to time that they may be preparing for themselves the defence of an infringement suit; the object, therefore, was to put these companies together. The object and the reasons were generally what I have stated—for the purpose of mutual protection, advantage, and defence, because in every place in Europe there are lots of clever fellows who will make and sell lamps on the patent of Mr. Edison and Mr. Swan and pocket the benefits if we let them. Now we shall be much stronger and united against infringers by having both sets of patents under our control; and besides, in a place in which one patent may be weak in another it may be strong. We then come to the delicate point in all such negotiations—the relative value. It is very difficult to find out and appreciate the relative value of what is partially unknown, because, although we have heard of the Swan and Edison lamps for a good many years, the business is still, so to speak, in its infancy. It is a great undeveloped business, and the development of that business would depend very much, if we remained distinct companies, upon who won the suits. If the result of that litigation was to bar the Swan Company from manufacturing lamps all over Europe, and to give the Edison Company, so to speak, the monopoly of that manufacture, the relative portions or values would be greatly altered. Those questions have never been brought to issue. We have had to resort to the only known factor which influences men's minds in the circumstances, that is, having both gone on the theory that the patents were valid patents. We have each done a business, we have each a going concern. The businesses have been founded on different principles. We, for instance, have paid cash for our patents; the other people have bound themselves to pay royalties on their patents. We have spent a great deal of money in these foreign countries in bringing our business to its present standard of expansion—well, we have gone on the simple factor, how much work had we done, how many lamps had we manufactured and sold. That seemed to be one reasonable factor. That had to be modified by some considerations. For instance, if these suits which are pending in different countries—in Germany, in France, in Austria, and in Belgium—if they should go absolutely against one company or the other, that would be a very disturbing factor; or if the result was to throw these patents open to all the world, we should both be in a bad state. Many people would hesitate to attack a united company, but no one would, if the result of the action of the two companies was to proclaim to the world that the patents were not binding and were open to all. We have taken similar views on both sides of the relative value of that factor. Fortunately, the method of computing the proportions does not involve the necessity of dealing with the capital of either company; in going into the question of what it has cost "A" or "B" we have taken the factor of the business actually done as the basis of the future division of the profits of the business. The thing was to get rid of this litigation, and to proceed as a united company to extend the business. The administration costs will probably be somewhat diminished. The efficiency of the lamp will be greatly improved, the public mind will be set at rest, there will be no alarming forebodings that people may be challenged as infringers and subject to legal proceedings. The business will increase; with the increase of numbers the profits on lamps will greatly increase. This is one of those businesses where a comparatively small number of lamps means a profit inconsiderable in comparison with a much larger output. The charges are comparatively great on the small quantities, and are greatly diminished on the increased output. Supposing, on an output of a quarter of a million, you make a shilling a lamp; if you increase the output to half a million, the profit may be 1s. 6d. What we think is, that our plan of putting these conditions together will effect a double object—not only increase the output, but it will reduce the cost of each individual lamp, so that the profit will be greater.

In order to express in legal language what I have told you in so few words, it has been necessary to enter into an agreement with this continental company of Paris, and I had better perhaps briefly, before submitting the agreement to you for your information, go through the different articles, so that you can understand exactly what it is. It is to be a union of the two companies, and is to be called the Company General of Incandescent Lamps. The duration of the Company is to be fixed by the statutes up to December 31, 1894, that being in fact about the day, or a little beyond the day, when the patents of both Edison and Swan lamps die. It is a few weeks in case of the necessity of winding up the companies. In that event there would be time to do it; but that term may be prolonged or reduced, if the necessity should arise, by the resolution of a special meeting called for the purpose, but only when such resolution is passed by a majority of three-fourths of the share capital of the Company. I cannot myself see any reason to believe that, during the term of the patents at all events, there will be any necessity to interfere with this as a going concern. I think it is exceedingly likely that if the business is managed with tolerable prudence that at the end of the six years you will have a well-established going concern not protected by patents—which will then be open to all the world—but probably protected by improved processes which in the interval may be patented; at all events, if not that, by a large connection all over Europe and by a trade-mark which I hope will have behind it the character of the most efficient and best incandescent lamp which can then be produced. If that be so, this Company would go on. It would go on, I suppose, on conditions which we need not even anticipate now, but I should think possibly very much on the conditions of this agreement. I must tell you that this is to be a French company—that is to say, a société anonyme, which is equivalent to our limited liability. The seat of the Company will be in Paris, but may be transferred to any other place. What do the parties bring in? This is an arrangement based on bringing in a going concern, or rather two going concerns; we propose to bring in what we have got, and they propose to bring in what they have got. What they would bring in is France, Belgium, Austria, Hungary, and Spain. That is where the Edison patents are under the control of this Company. We bring in France, Belgium, Russia, Austria, Hungary, Italy, Sweden, Norway, and Portugal. There is one important area entirely left out—that is Germany. The gentlemen in Paris have not the power of controlling the Edison interest in Germany, and, as I have had occasion to tell you at some of our meetings, in Germany, amongst other places, we are in litigation. But it is not impossible, when this preliminary step has been taken, Germany may follow. However, Germany is excluded from this agreement, the reason being that they cannot bring in Germany. There is one point of importance which I should be very glad to make clear. I said that this business had been founded on different principles; whereas we out and out bought the Swan patents by shares and money, the foreign people submitted themselves to a tax, or license, or royalty, I think, is the proper term, of 20 centimes a lamp. This has been one of our great bones of contention and difficulties, these 20 centimes. Well, it is the payment made to Mr. Edison for bringing in his brains and patents. In France he got a royalty of somewhat under 2d. on all the lamps manufactured within the area of these patents. We have had to look at that, amongst other things, and we have seen fit—I do not know that I need enter too largely into the discussion of why, as a matter of prudence, and after full consideration—to accept that 20 centimes as a charge on the old business, but only for the duration of the patents. Now, that is one of the points which made us insist so strongly upon each party bearing its own burden. The contract was that 20 centimes should be paid as long as the Company existed. We have agreed that it shall be paid till the end of the patents. I have told you what everybody brings in, and the consideration for bringing it in is the creation of a certain quantity of shares representing what has been done heretofore—what I may call the cost of the affair up to date—and a further amount of shares representing the capital which it will be necessary to find to develop this business from time to time. Now, it is not a big thing; you need not be alarmed by supposing you have immediately to find more capital. The share capital of the Company is to be 2,000,000f., which is £80,000, of which 1,000,000f. is to represent in fully-paid shares the values of the going concern as put into the common pot, and the other

1,000,000f. is to be made up of cash contributed by the Companies in the respective proportions in which the profits of the united concern are to be divided. The division of these profits was a very anxious matter, and I think you may give us credit for having been ourselves largely interested—not that I think the mere pocket influence is the full consideration which ought to bind honourable men acting in the interest of others; but still it has a certain interest. But being, first of all, large shareholders, and, what is more, being the implicitly-trusted directors of this Company, we made the hardest possible fight about the proportion; and I think Mr. Leyland, who has taken an immense deal of pains over this matter, will agree with me that we have reason to be very well satisfied with the proportions brought out. We think that, looking at the relative work done by the two Companies; looking at the risks of litigation in these different countries; looking at the position which these people have got into in France, Belgium, and Austria by combinations which they have made with important people—that they stood upon the very nature of the thing to do a bigger business than we did; that is to say, that their chances, if we had gone on even in friendly way, were of a character to give them a better business than ours. Then there was the great risk of our failing on these patents, and that was a very serious matter; so that altogether the Directors are quite satisfied, and are prepared to take all the responsibility of recommending you to accept the proportions. I have told you what the respective proportions of the Company are to be in consideration for their contributions. There shall be allotted to the Continental Company 1,200 shares, and to the Swan Company 800, of 500f. each, fully paid-up. That represents the million of francs which I told you would be represented in shares of the going concern. The other 2,000 shares are to be subscribed, 1,000,000f. in cash in the same proportion as the above contributions, and we shall have to find £16,000 and these gentlemen will have to find the balance—£24,000—and the profits realised in the future will, of course, follow the shares. Of every £100 profit made they get 60 per cent., and we get 40 per cent., and we think, looking at the matter all round, it is a very satisfactory bargain, and the more one looks at it the more satisfied he becomes. By uniting these companies on these conditions we get rid of the litigation, and shall be able to build up a trade-mark and a business of great value by the time of the expiration of the patents. We think we have done very well indeed, looking at the outlay of the two companies, in arranging for that amount of the net profit, because, after all, the number of shares represents the concrete value, which works out at 60 per cent. and 40 per cent. respectively. Under the arrangement the two Companies are put together as a going concern in these countries, and there is an end of all litigation—each party withdraws from the litigation and pays its own costs. One very important matter is this: Suppose in the interval there should arise some unforeseen—as far as the present goes—necessity for terminating this bargain, which could be done in general meeting, recommended by the Directors, each Company would return to the *status quo ante bellum*, or, perhaps I should say, *ante pace*, with all its rights intact, but not with its right to litigate. Therefore, if at the end of two or three years we should dissolve the partnership—which I cannot foreshadow—it has been provided for; it would not mean a revival of litigation. Neither party can challenge the rights of the other in the future, and that seems to be a matter of some value looking at the cost of this litigation. Then, there is the capital. We get 1,000,000f. as representing what we put in in fully paid-up shares, and I may say in the presence of a couple of distinguished lawyers, one English and the other French, that the recent decision does not affect the rights of any company to do what we are doing—it represents so many thousands paid down to carry on the business. These are the general terms of the agreement, but there are some exceptional things I ought to call attention to.

The only charge resting on the business, over and above the cost to the parties, is that 20 centimes, and we, for reasons which are satisfactory to our minds, thought it better to accept that for the term of the patents. But there are some other conditions. We were pretty free all over Europe. We had not committed ourselves very much; they had. They had made bargains with a very important firm well known in this country—Sir William Siemens and Co., who are equally powerful people in Germany and elsewhere abroad. They were large manufacturers or installers of electricity abroad, and they had made contracts with the Edison Company under which, in Austria-Hungary and Russia, they are entitled to manufacture lamps, as lessees, upon the terms of certain royalties to the parent Company. We have had to face these different arrangements, and there is no getting rid of the bargain with Siemens; but what we have stipulated is that all benefits arising under that shall come into the common pot. Siemens pay 37½ centimes for the right to manufacture the lamps, and they manufacture on a considerable scale, though not so large as to interfere with the scope of our company. They may like to take our lamps at the trade price, or make lamps themselves and pay the royalty, and the parent company undertake to hand these royalties over. They have similar arrangements with the Italian society and with a large firm in Belgium, and whatever the profits are they will come into our pot; they are not entitled to make any charge for doing the work, and we have the power of control to the extent of examining their books. We have reserved for our company the right to manufacture lamps in Germany and sell them as long as the law will allow us, and if anybody chooses to buy lamps in Hamburg or any of the German ports for export, not to Great Britain, but to any parts of the world where there are no patent laws, we shall be free to do that business. This is the general character of the bargain, though of course there are a great many details. The French Company have other business besides lamp-making, such as the manufacture of dynamos; but we shall not enter into these. The fusion, of course, involves articles of association and the appointment of the direction. Therefore it becomes a matter of confidence. We are very well satisfied with the outcrop of the discussion. Of course we go in as the minor factors, and we were careful to consider how that minor factor was to be protected from being overridden and outvoted by the major factor. What we did was to get three Directors out of a board of seven. That still leaves the governing power in the hands of our French friends; but we could not reasonably claim more. The Directors would be nominated for the whole term of the agreement, and it is for the shareholders to say whether they will run the risk of so nominating their Directors. The French company have nominated Messieurs Bernard, Chatard, Rau and Porgés, while your interests will be represented, if you approve of this agreement, by Mr. Leyland, Mr. Simon—our agent in Paris since the formation of the company, a man of exceptional intelligence and straightforwardness—and myself. Article 12 decrees what is to be done with the net proceeds, after deducting the working expenses. There is to be a reserve fund of 5 per cent., which is according to the common law of France; 6 per cent. interest on the shares; then from the balance shall be set apart 10 per cent. for the Board of Directors, to be distributed amongst the members in equal parts. Thus, if the shareholders do not get 6 per cent. the Directors will get nothing. I beg now to move: "That the agreement now submitted, dated May 5, 1888, and made between the Swan United Electric Light Company, Limited, of the one part, and the Compagnie Continentale Edison de Paris, of the other part, be and the same is hereby approved, and that the Directors be empowered to do all acts necessary for carrying such agreement into effect and constituting the new Company, and to enter into a further agreement to be made with such new Company." The Chairman explained that the further agreement referred to a bargain with the Edison and Swan Company not to make lamps for exportation to those countries protected by Swan's patents.

Mr. Leyland seconded the motion, and expressed an opinion that when the new arrangement was found to work well, Germany would reconsider its position and come to similar terms. He recommended entering into the agreement which had been described by the Chairman as the very best thing the Company could do.

The motion was carried unanimously, and the proceedings closed with a vote of thanks to the Chairman.

FACETIÆ.

THE LUMINOUSLY BRIGHT YOUNG MAN (after "Patience"), by Henry Hine:—

I.—If you're anxious for to shine
In the electric lighting line,
As a man of science bold,
You must run down torches flaring,
Lamps and gas and candles glaring,
And sneer at them as old.
You must crack up commutators,
Armatures and indicators,
Quantity, intensity and field of force,
Incandescence, insulation,
And magnetical rotation,
Which is soon to light the world, of course.
And every one will say,
As you walk your brilliant way,
If this young man is such a bright young man,
As to be too bright for me,
Why, what a very luminously bright young man,
This bright young man must be.

II.—If you want to sell a plant,
You must get up all the rant,
You can crowd into your brain,
You must shoot it off your tongue,
To the people you're among,
Like a limited express train,
You must make all men believe,
That you never do deceive,
You'd rather burn your tongue off in the fire
And this in spite of knowing,
While the words are from you flowing,
That you're a most outrageous liar.
And every one will say,
As you walk your brilliant way,
If this young man is such a bright young man,
As to be too bright for me,
Why, what a very luminously bright young man,
This bright young man must be.

III.—Your lamps for incandescence
Are the concentrated essence
Of all that makes good light,
Your dynamos most efficient,
Your experts are omniscient,
Your joints all soldered tight,
The other fellow's stuff,
Is very crude and rough,
His arguments poor and lame.
Follow close these admonitions,
Steer clear of electricians,
And you'll get there all the same.
And every one will say,
As you walk your brilliant way,
If this young man is such a bright young man,
As to be too bright for me,
Why, what a very luminously bright young man,
This bright young man must be.—*Western Electrician.*

PROVISIONAL PATENTS, 1888.

MAY 25.

7655. **Improvements in and connected with underground conductors of electricity.** Rookes Evelyn Bell Crompton, Arc Works, Chelmsford.

7679. **Improvements in electric lamps.** John George Sowerby and Charles John Chubb, 11, Wellington-street, Strand, London.

7696. **Improvements in incandescent electric safety lamps.** Theophilus Coad, 1, Quality-court, W.C.

MAY 26.

7748. **An electric motor for clocks, watches, and other similar apparatus.** Louis Hoppe and Günther Hoppe, 33, Southampton-buildings, Holborn, London.

7750. **Improvements in electric arc lamps.** Julien Dulait, 28, Southampton-buildings, London, W.C.

MAY 28.

7761. **Improved method of applying electricity to a general system of traction.** Charles Barnard Burdon, 32, Holborn-hill, Higher Tranmere, Cheshire.

MAY 29.

7805. **Improvements in the method of and apparatus for the production, transmission, and distribution of electric currents.** Herbert John Allison, 52, Chancery-lane, London. (Charles Edgar Fritts, United States.) (Complete specification.)

7826. **Improvements in galvanic generators.** Harry Barringer Cox, 46, Lincoln's-inn-fields, London, W.C. (Complete specification.)

7848. **Improvements in or relating to indicators for alternating electric currents.** William Phillips Thompson, 6, Lord-street, Liverpool. (George Westinghouse, Junior, United States.) (Complete specification.)

7849. **Improvements in or relating to apparatus for detecting and locating faults in alternate electric circuits.** Wm. Phillips Thompson, 6, Lord-street, Liverpool. (George Westinghouse, Junior, United States.) (Complete specification.)

7850. **Improvements in or relating to alternate current electric distribution.** William Phillips Thompson, 6, Lord-street, Liverpool. (George Westinghouse, Junior, United States.) (Complete specification.)

7851. **Improvements in switches for electric circuits.** William Phillips Thompson, 6, Lord-street, Liverpool. (George Westinghouse, Junior, United States.) (Complete specification.)

7852. **Improvements in or relating to central-station apparatus for system of electric distribution by alternate currents.** William Phillips Thompson, 6, Lord-street, Liverpool. (George Westinghouse, Junior, United States.) (Complete specification.)

7853. **Improvements in or relating to storage batteries.** Wm. Phillips Thompson, 6, Lord-street, Liverpool. (Charles David Paige Gibson, United States.) (Complete specification.)

7876. **Improvements in electric batteries.** Benjamin Willcox, 47, Lincoln's-inn-fields, Middlesex. (Bruno Abdank Abakanowicz and Arsène d'Arsonval, France.)

MAY 30.

7901. **Improvements in the construction of electro, medical, and other magnets.** James Joseph Horne, Longham, Gressenhall, East Dereham, Norfolk.

7910. **Improvements in holders for incandescent lamps.** Fredk. Thomas Schmidt, Sunbridge Chambers, Bradford, Yorkshire.

7916. **Improvements in transmitting written or other characters, figures, drawings, plans or the like, and also indicating and recording the indications of registering instruments by electricity and in apparatus therefor.** Thomas O'Brien, 6, Bank-street, Manchester.

MAY 31.

7977. **Improvements in the mode of filling secondary battery plates.** Henry Gurney Morris and Pedro Grotjan Salom, 320, High Holborn, London, W.C. (Complete specification.)

7998. **Improvements in and relating to shades and reflectors for incandescent electric lamps.** Frank Holman, 45, Southampton-buildings, London. (Complete specification.)

COMPLETE SPECIFICATIONS ACCEPTED.

MAY 31, 1887.

7865. **Improvements in dynamo-electric and electro-dynamic machines.** Frederick George, Uley, Dursley, Gloucestershire.

JULY 13, 1887.

9843. **Compensating electric measuring instruments for temperature.** Walter Thomas Goolden and Sydney Evershed, 2, Victoria Mansions, Westminster, S.W.

JULY 28, 1887.

10,519. **Improvements in posts, such as fencing telegraph, direction, lamp, and other similar posts.** James Bazeley Petter, 34, Southampton-buildings, London, W.C.

JULY 30, 1887.

10,606. **Improvements relating to the distribution, storage, and regulation of electric currents.** Léon Gerard, 433, Strand, London.

AUGUST 4, 1887.

10,748. **Improvements in portable batteries for the production of electric light.** Alexander Schanschieff, Gipsy-hill, Surrey.

SEPTEMBER 17, 1887.

12,645. **Improvements relating to means for carrying electrical batteries for driving tramway vehicles, and for other purposes.** William Danton Sandwell, 4, South-street, Finsbury, London.

SEPTEMBER 26, 1887.

13,005. **Electrical automatic boxes for the delivery of small articles.** Frank Villiers-Stead, Elward Radford Hedgman, and James Spratt, 1 and 2, George-street, Mansion House, E.C.

OCTOBER 14, 1887.

13,954. **Improvements in or appertaining to electrical railways.** William Edwin Irish, 52, Chancery-lane, London.

JANUARY 31, 1888.

1406. **Portable combined electric and mechanical clock alarum.** Mary Turton and Samuel Turton, Dudley-road, Tipton.

FEBRUARY 7, 1888.

1851A. **A sound conveying tube for telephones, graphophones, and like instruments.** James Yate Johnson, 47, Lincoln's-inn-fields, Middlesex. (The Volta Graphophone Co., Incorporated, United States.) Note.—This application having been originally included in No. 1851, dated 7th February, 1888, takes, under Patents Rule 23, that date.

FEBRUARY 14, 1888.

2218. **Improvements in compasses, calipers, and analogous instruments.** Joshua Stevens, 169, Fleet-street, London.

MARCH 20, 1888.

4273. **Improvements in the method and means for increasing the frictional contact between the wheels and rails in railways.** Alfred Julius Boult, 323, High Holborn, Middlesex. (Elias Elkan Ries, United States.)

MARCH 24, 1888.

4524. **Improvements in portable galvanic batteries.** William Joseph Starkey, Barber-Starkey, 70, Market-street, Manchester.

APRIL 27, 1888.

6237. **Improvements in jars or cells for primary or secondary electric batteries.** Adam Millar, 62, St. Vincent-street, Glasgow.

MAY 1, 1888.

6416. **Improvements in galvanic elements.** Louis Hoppe and Günther Hoppe, 6, Annette-road, Loraine-road, Holloway, London, N.

6481. **Improvements relating to the electrical transmission of power and to apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Nikola Tesla, United States.)

6502. **Improvements relating to the generation and distribution of electric currents and to apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Nikola Tesla, United States.)

SPECIFICATIONS PUBLISHED.

1887.

6875. **Treating indiarubber.** A. M. Wood. 6d.

7235. **Electric arc lamps.** F. C. Phillips and H. E. Harrison. 8d.

7802. **Ammeters and voltmeters.** W. E. Ayrton and J. Perry. 8d.

7829. **Automatic transmission of steno-telegraphic signals.** W. H. Beck (Cassagnes.) 8d.

7834. **Controlling, &c., electric currents.** H. Edmunds. 8d.

8214. **Telephone systems.** W. P. Thompson (Mauritius). 1s. 3d.

8714. **Mariners' liquid compasses.** W. J. Reynolds. 8d.

9256. **Regulating the speed of dynamos.** J. L. Yuly and W. H. Andrews. 8d.

9570. **Railway signals, &c.** H. Williams. 8d.

13,069. **Harmonic telegraphy.** Van Rysselberghe. 11d.

14,062. **Automatic medical apparatus.** E. Puller. 8d.

15,537. **Electric Switches.** R. W. Paul. 8d.

17,047. **Secondary batteries.** F. King. 8d.

1888.

137. **Producing induced electric currents.** J. C. Pürthner. 8d.

3075. **Electric arc lamps.** A. W. Southey. 6d.

3215. **Electric incandescent lamps.** J. W. Oldroyd. 6d.

3235. **Multipolar dynamo electric machines.** G. Miot. 8d.

4277. **Electro-mechanical movements.** A. J. Boult. (McLaughlin.) 8d.

4280. **Increasing frictional contact between the wheels and rails in railways.** A. J. Boult. (Ries and Henderson.) 8d.

4929. **Magneto-electric generators.** W. Gillett and G. Haseltine. 6d.

1882.

1363. **Secondary batteries.** F. Maxwell-Lyte. 8d. Second edition.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednes-day-
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	4
26 April	1%	Anglo-American	100	37
26 April	2%	— Pref.	100	62
12 Feb., 85...	5/0	— Def..........................	100	12¼
28 Mar.	3/0	Brazilian Submarine.........	10	12½
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	10
28 Mar.	2/0	Direct United States	20	8¾
12 April	2/6	Eastern	10	12
12 April	3/0	— 6% Pref.	10	14¾x
1 Feb.	5%	— 5%, 1899	100	111
26 April	4%	— 4% Deb. Stock	100	108
26 April	3/6	Eastern Extension, Australasia & China............	10	13
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	103½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5⅞
12 April	3/0	— 6% Pref.	10	13⅞
30 April	5/0	Great Northern...............	10	14

Dividend.		Name.	Paid.	Price. Wednes-day
1 Mar.	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17
11 May	37/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	6x
16 Mar.	5%	Maxim Weston	1	⅛
26 April	2½	Oriental Telephone	11	$\frac{7}{16}$
26 April	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2¼
15 Feb.	15½%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	14⅞
......	...	West African..................	10	5
1 Mar.	5%	— 5% Debs.	100	92¼
29 Dec.........	6/0	West Coast of America ...	10	6⅛
31 Dec.	8%	— 8% Debs.	100	117
11 May	9/	Western and Brazilian......	15	10⅛
11 May	6/10½	— Preferred	7½	6⅝
11 May	2/1½	— Deferred...................	7½	4
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	11¼
13 May, '80...	...	— 6% 2nd Pref.	10	6½
2 May	7%	West Union of U.S..........	$1,000	123
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of May ...	£40,586	+ £1,376
Brazilian Submarine	W. June 1 ...	£3,376	...	Great Northern	M. of Apl. ...	21,400	...
Cuba Submarine..................	M. of May ...	4,437	+ £736	Submarine	None	Published.	
Direct Spanish.....................	M. of May ...	1,800	+ 119	West Coast of America	M. of Apl. ...	4,405	...
— United States	None	Published.	...	Western and Brazilian	W. June 1 ...	2,675	...
Eastern.............................	M. of May ...	49,003	+ 8,446	West India and Panama	F. April 30 ...	3,268	+ 231

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Western Counties and South Wales Telephone Company.—The Directors of the Western Counties and South Wales Telephone Company announce a dividend of 6 per cent.

Hastings Electric Light Company.—At the annual meeting of the Hastings Electric Light Company, a dividend of 3 per cent. was declared. The gross profits were £558. 18s. 7d.

Direct Spanish Telegraph Company.—The traffic receipts of the Direct Spanish Telegraph Company for the month of May amounted to £1,800, against £1,568 in the corresponding period last year.

Eastern Telegraph Company.—The Eastern Telegraph Company's traffic receipts for the month of May, 1888, amounted to £49,003, compared with £48,057 in the corresponding period of 1887.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ending May 25 amounted to £4,125; and for the week ending June 1, £3,376.

The American Edison Incandescent Lamp Patents.—It is announced that Mr. Arthur Shippey has been retained as an expert witness by the Westinghouse Electric Company in the legal proceedings pending in the U.S A.

Union Electrical Power and Light Company.—Mr. H. Evans Broad (Broads, Paterson, and Co., chartered accountants) has been appointed by Mr. Justice Chitty official liquidator of the Union Electrical Power and Light Company.

The Sawyer-Man System.—Mr. Frank Ritchell, of New York, the authorised agent of the Sawyer-Man Electric Company, is at present in London making arrangements for the introduction of the Sawyer-Man system of electric lighting.

Eastern Extension Telegraph Company.—The traffic receipts of the Eastern Extension, Australasia and China Telegraph Company, for the month of May, 1888, amounted to £40,586, compared with £36,495 in the corresponding period of 1887.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company for the half-month ended May 31 are £2,991, as compared with £3,438 in the corresponding period of last year. The February receipts, estimated at £6,449, realised £6,625.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during May was 4,437, estimated to produce £3,300, against 4,040 messages, producing £3,061, in the corresponding month of last year. The traffic receipts for February, estimated at £3,600, realised £3,666.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ending May 25, after deducting the fifth of the gross receipts payable to the London Platino Brazilian Telegraph Company, Limited, were £3,366; and for the week ending June 1, after deducting the fifth of the gross receipts payable to the London Platino Brazilian Telegraph Company, Limited, £2,675.

United Telephone Company.—The Directors of the United Telephone Company have decided, subject to audit, to recommend, at the forthcoming general meeting, a dividend for the second half-year ending April 30, 1888, at the rate of 10s. per fully-paid share, and 5s. the new shares, making, with the interim dividend paid on December 2 last, a total dividend for the 12 months ending April 30 last of 15 per cent. Dividend warrants will be posted on July 3.

The Telephone Market.—The monthly circular of a firm of stockbrokers which devotes special attention to telephones says:—Telephones have been a quiet market, and prices close flat. The negotiations for the amalgamation of the various interests hang fire. The radical vice which has characterised all the operations of the United Telephone Company since its formation—namely, endless procrastination and discussion in place of action—is no doubt the cause. The shareholders of this company, having received good dividends, seem quite content to remain ignorant of, or to ignore, the shortcomings of their Directors. But for the happy accident that subsidiary companies were formed whereby the management in certain district was transferred to abler hands, the United Company's dividends would have been small. The Company, in fact, is to-day successful, not owing to the exertions of its management, but really in spite of the fact that its best interests have been neglected, and its most important field of operations left practically unworked.

Consolidated Telephone Company.—The report of the Consolidated Telephone Construction and Maintenance Company, Limited, for the year ended March 31, 1888, states that the net profit amounts to £10,788, which, with the amount carried forward from last year, leaves a balance of £12,484 for disposal, after making provision for doubtful debts. It is proposed to pay a further dividend of £2. 17s. per cent, making, with the interim dividend paid in November last, £5. 7s. per cent. for the year, writing off the sum of £541 for depreciation of plant, machinery, and furniture, and the sum of £2,000 from the Edison-Gower-Bell Telephone Company securities, thus leaving a balance of £1,372 to carry forward. The Directors have received a further sum of £4,427 on account of profit arising from the liquidation of the River Plate business, which is included in the above statement, and there is still a further considerable amount to be received under that head. They have received an interim dividend at the rate of 5 per cent. on the shares of the United River Plate Telephone Company, which is also included in the foregoing.

NOTES.

Japan.—A central station is to be shortly opened at Yokohama on the Gülcher system.

Motors for Paris.—Sprague motors in considerable quantities have been ordered for Paris.

Vienna.—The number of lamps in the Vienna Town Hall will be shortly increased from 650 to 2,000.

Electric Light Act.—The Electric Light Amendment Act has passed through Committee in the House of Commons.

Maxim-Weston Company.—The meeting of shareholders of this company takes place to-day. A lively meeting is expected.

Gas and Electricity in France.—The gas company at Epernay have decided shortly to establish an electric central station in that town.

Motor Installation.—San Francisco, California, is going ahead with distribution of electric power for motors. It has 700 motors at work, employing five circuits.

Electric Fishing.—Some German sea fishermen are making experiments with the electric light for night fishing, and so far the results have been highly satisfactory.

Electric Physiology.—M. Augustus Waller read a paper on 28th May, before the Société Savantes, on "The Determination of the Electromotive Action of the Human Heart."

Licence for St. James's.—The St. James's and Pall Mall Electric Light Company were yesterday week granted, by the Vestry, a license for the supply of the electric light in the parish of St. James's.

Derby.—Messrs. John Davis and Son, who supply the light to the exhibition at Derby, are intending, we understand, to put down a large electric plant at their premises, All Saints' Works, for supplying the neighbouring shops.

Paris.—The Edison Continental Company has commenced work for the establishment of a central station at the Palais Royal, Paris. The machinery is to be fitted underground. The station will contain six Edison dynamos for 1,000 lamps each.

Italian Exhibition.—The theatre at the Italian Exhibition is lighted entirely by electric light from the Thomson-Houston incandescent dynamo. There is not a single gas-bracket about the place. The lamps are arranged to be turned up or down as desired by a variable resistance.

The Gas Company can do it.—At Verona a local electric light company which was formed for establishing a central station, not being able to fulfil this object, the gas company has been authorised by its shareholders to take the matter in hand, and turn the dynamos for the Veronese.

Electric Traction in Berlin.—The Schwartzkopf Company, of Berlin, have just constructed a new electric tramway. The current is furnished by a battery of 60 cells, with a capacity of 320 ampere-hours. The motor is a disc dynamo, with double winding on the armature, and two commutators.

Slate Bases Not Good Enough.—The installation at the Burg Theatre, Vienna is now complete, but the Vienna Society of Electricians, having officially examined it, have declared that the insulation furnished by the slate bases of the cut-outs and other similar parts is not sufficient for them to pass the installation.

Large Installations.—One of the largest, if not the largest, central electric station at present working is that of New Orleans, where the Louisiana Electric Light and Power Company have an installation of 1,500 arc lights, with 350 miles of circuit. Plant for 1,800 incandescent lamps has also recently been added to the system.

Royal Meteorogical Society.—At the ordinary meeting of the society, to be held at the Institution of Civil Engineers on Wednesday next, among others, the following paper will be read:—"First Report of the Thunderstorm Committee: On the Photographs of Lightning Flashes," drawn up by the Hon. Ralph Abercromby, F.R.M.S.

Milianah.—The town of Milianah, in France, is to be lighted with electric light, under the direction of M. George Gally. The installation will have two 300-light dynamos, driven by a turbine of 60 h.p., at a distance of 500 yards from the town. The streets will be lighted with seventy lamps of 16 c.p., and twenty lamps of 50 c.p. The installation is to be ready by July 14.

Electric Lights on the Railway.—On a block system of the South Pacific Railway, California, the oil lamps in the signals are replaced by Swan incandescent lamps on an arc circuit. Forty trains after dark run on this line, and the electric lamps are not blown out by the high winds, as is the case with the oil lamps, and two less men are required to clean the lamps.

The Poetry of Induction.—

"Around the magnet, Faraday
Is sure that Volta's lightnings play;
But how to draw them from the wire?
He took a lesson from the heart;
'Tis when we meet, 'tis when we part,
Breaks forth the electric fire."

Blackwood's Magazine.

Irish Exhibition.—The electric lighting at the Irish Exhibition is that permanently installed at the opening of Olympia, with groups of six-starred arc lamps in lanterns, which make this one of the best-lighted halls to be seen. Messrs. Edmundson and Co., Limited, the well-known electrical engineers, of Great George-street, Westminster, exhibit some models and specimens of their lighthouse fittings.

Royal Society.—The following papers, by Mr. G. Gore, F.R.S., were read yesterday before the Royal Society:—(1) "The Minimum Point of Change of Potential of a Voltaic Couple." (2) "The Change of Potential of a Voltaic Couple by Variation of Strength of its Liquid." (3) "Influence of the Chemical Energy of Electrolytes upon the Minimum Point and Change of Potential of a Voltaic Couple in Water."

Magnetic Filter for Old Oil.—A new process has been invented for cleaning lubricating oil that has once been used, so that it can be used again. The oil is poured gently over a bed of iron which is strongly magnetised. The heaps of iron fragments constitute a magnetic sponge which stops all the particles of metal, especially those of iron. The oil is then passed through two hair filters, and comes out perfectly clean.

Accumulators on Board Ship.—It is satisfactory to note that accumulators are to be employed in connection

with the electric light installation which is being put into the Queen's yacht "Victoria and Albert." The battery is to consist of forty of Messrs. Drake and Gorham's latest type ship-lighting cells, which will be used in conjunction with a special switch-board designed by the same firm, and fitted with their patent ring contact switches.

Incandescent Lamps for Boiler Inspection.—Mr. E. Blass, a German scientist, has used an incandescent lamp for actual inspection of the inside of boilers under steam. A thick glass tube was introduced through a stuffing box, a small incandescent lamp was lowered into this, and lighted by means of a small battery. By this means the whole of the boiler was lighted up, and could be inspected through a thick glass plate inserted in the boiler.

Election F.R.S.—The new members elected by the Royal Society are:—Thomas Andrews, F.R.S.E., James Thomson Bottomley, M.A., Charles Vernon Boys, Arthur Herbert Church, M.A., Prof. Alfred George Greenhill, M.A., Lieut.-General Sir William F. D. Jervois, R.E., Prof. Charles Lapworth, LL.D., Prof. T. Jeffery Parker, Prof. John Henry Poynting, M.A., Prof. William Ramsay, Ph.D., Thomas Pridgin Teale, F.R.C.S., William Topley, F.G.S., Henry Trimen, M.B., Prof. Henry Marshall Ward, M.A., and William Henry White, M.I.C.E.

Cut-Outs.—The best general rule for the use of cut-outs is not, that each branch from a larger wire should have a cut-out at the junction, as often insisted upon in specifications, but as follows:—(1) Every main to be protected by a single-pole cut-out on each cable, negative and positive, and every branch main to be similarly protected with two cut-outs; and (2) every group of lamps, either in a row, or in an electrolier, up to the number of 10 or so, to be protected by a single-pole cut-out (or by a double-pole cut-out if preferred); and (3) every single pendant having its junction off the main should have a double-pole cut-out.

Speed of Electricity.—According to Prof. Gould's investigations, it appears that aerial telegraph wires on poles transmit electricity at the rate of from 14,000 to 16,000 miles per second, and that the velocity of the transmission increases with the distance between the wires and the earth, or, in other words, with the height of suspension; and that subterranean wires, like submarine cables, transmit with reduced rapidity. Again, while wires suspended at a feeble height are known to transmit signals at a velocity of some 12,000 miles per second, those that are suspended higher give a velocity of from 16,000 to 24,000 miles.

Damage by Lightning.—In Mr. Reginald Jones' paper on "Breakdowns," the question was asked whether cases were known where lightning had damaged installations. At Seward, in Nebraska, there is a 600-light installation on the Westinghouse transformer system, which has been working well for some time. During a recent storm the lightning struck the wires and broke down seven convertors. The circuit was temporarily deranged, but the damage was not as great as might have been expected, and by rewinding a portion of the convertor and borrowing a few others the trouble was remedied without much delay.

Origin of the Aurora Borealis.—M. Luvini has expounded a theory of the aurora borealis. The friction of the particles of water, ice, and, accidentally, of other substances caught up by the violence of the atmospheric disturbance into the higher regions, and dispersed in the upper layers of the air many miles high, is the source of the atmospheric electricity, thunderstorms, and the aurora. The discharges of this electricity takes place in the same manner in auroras as in thunderstorms, the only difference being their intensity; and it is owing to these discharges in the rarefied air that the light of the aurora has its origin.

Toulouse.—The central electric light station at Toulouse will shortly have a great extension. It has been established now some months, and the director, M. de Chanteau, has now obtained permission from the authorities to run his conducting mains along the main sewers, and he will also be able to utilise the falls at Bazacle, from which power can be obtained up to 1,200 h.p. The gas company at Toulouse had been contemplating for some little time setting up a central station of their own, but, in the usual manner, have left the matter sufficient time for their competitor to put up an installation, and become master of the situation.

Aphorisms for Gas Companies.—"What difference does it make to a gas company whether the money expended on improvements be for gas-holders and mains, or for dynamos, boilers, and wire?" "Consumers *will* have the electric light, if it costs twice as much as gas. It is good policy for the gas companies to recognise this fact, and govern themselves accordingly." "The introduction of an incandescent plant into the business district of a town means the loss of a five-foot burner for every incandescent lamp used." "Gas companies are much more favourably situated for furnishing arc and incandescent lamps and electric power than anyone else—*at present.*"

Benevolent Society.—The 12th annual meeting of the United Kingdom Postal and Telegraph Service Benevolent Society was held last week in the Town Hall, Oxford. About 120 delegates from various parts of the country were present. In the evening the delegates were entertained at dinner by the staff of the Oxford branch of the society, the Postmaster of Oxford presiding, supported by the Mayor and other gentlemen. The society numbers upwards of 13,000 members, the increase during the past year being over 1,300. More than £56,000 has been paid in benefits since the formation of the society. The next annual meeting is to be held at Belfast. It would be well if the electrical engineering industries were to imitate the example of our telegraph *confrères.*

Schanschieff Battery Company.—This company is still *in statu quo.* We have noticed a report in a French contemporary, that at a general meeting of shareholders it has been decided to wind up, and refund the money; but this is not the case. The company have taken very fine premises in Basinghall-street, and were laying themselves out for great business in mining and other lamps before the injunction was obtained, which is not yet settled. Even if settled satisfactorily to the company, it is hard to see how they can move business to the extent of their capital; and the directors are, no doubt, feeling this, and a readjustment of the amount of capital and the terms of purchase may possibly be looked for. If this be so, we shall look with some hopes that the company may be longer lived than many of its predecessors.

Hungary.—Most of the stations and flour mills of Hungary and many of the principal factories are using the electric light. At harvest time a portable installation is often used to pursue the work at night during the absence of the moon. The town of Temesvar has no other light. Many of these installations are undertaken by Messrs. Ganz

and Co., who are using the transformers of Zipernowski, Déri, and Blathy to a large extent. The travelling installation, mounted on a railway waggon, with dynamo and arc lamps, supplied by this firm, which was illustrated in this journal a few weeks ago, is greatly used for embarking or discharging troops by night. Messrs. Dollinger and Paragh, of Buda-Pesth, make electric apparatus for physicians and surgeons, and several other firms in Buda-Pesth, are actively engaged in various electrical developments.

Switzerland.—For some time past the transmission of electrical current for light and power by utilising the falls of the Swiss waters has been successfully carried out. A scheme of national importance is now mooted by a Swiss engineer, Herr Zschokke, of Aarau, for the purpose of utilising to a far greater extent the vast resources of water-power in Switzerland. It is calculated that in Switzerland some 68,000 h.p. is used in factories, of which two-thirds is water-power and one-third steam-power. For this latter, and for the locomotives, which take a further 175,000 h.p., large quantities of coal are imported annually from Germany, France, and Belgium—a total expenditure of 18,000,000f. Herr Zschokke proposes the construction of colossal reservoirs upon the various rivers, and the utilisation of these and the various waterfalls for the employment of electrical transmission of power instead of the continued use of steam and gas engines.

Electric Traction in France.—In the department of Haute-Savoie, a local railway is to be established on which electric traction is to be used. The concession has been obtained by Messrs. de Meuron et Cuénod, of Geneva, for a period of sixty-five years; a period of six months is to be allowed before commencement, and the entire line is to be opened within two years from the commencement of the work. A minimum is fixed of four trains per day each way. The following are the official conditions:—"The trains must be put in motion by electricity. For this purpose each carriage will carry a receiving dynamo-electric machine, put in communication by means of a copper cable laid the length of the line, with the generating machine driven by stationary steam-engines, placed at Monnetier, half the total distance. Each carriage must be mounted with an electric regulator, a friction break and an automatic break." This will be the first enterprise of the kind established in France, and its development will be watched with considerable interest in all parts.

Long-distance Telephoning.—The National Telephone Company, having a central office at Edinburgh, have connected that town with the surrounding towns in a network of communication, so that Edinburgh is now in telephonic communication with Glasgow, Paisley, Greenock, Ayr, Kilmarnock, Broughty Ferry, Newport, Perth, Forfar, Arbroath, Cupar, Kirkaldy, Dunfermline, Alloa, Clackmannan, Stirling, Falkirk, Grangemouth, Linlithgow, and other towns. The tariff for conversation is 6d., or one shilling for three minutes' conversation according to distance. Each of the subscribers by signing a simple agreement can converse on demand, from his own office or house, with subscribers in any of the other towns connected. A careful record of such connections is kept, and the company renders an account at the end of every month. They have issued a neat little pocket guide for the use of subscribers. In Switzerland, Genf and Lausanne are to be connected with Basle and Zurich on the Rysselbergh system.

School of Electrical Engineering.—The managers of the School of Electrical Engineering and Submarine Telegraphy, Hanover-square, have appointed Mr. Charles Capito, Member of the Institute of Mechanical Engineers, M.S.T.E. and E., to the post of Senior Instructor, shortly to be vacant by the resignation of Mr. Henry D. Wilkinson. Mr. Capito was for three years apprenticed to mechanical engineering works in Copenhagen, and studied for seven years in the Polytechnical Academy there, passing all the examinations with the highest honours. From there he went to Greenland, as a consulting engineer to the Krysolite Mining and Trading Company. He came to England (where he has since resided) in 1880, and for about two years held office in the City and Guilds of London Institute at Finsbury, under Prof. Ayrton, where several men now well known in the electrical world were his pupils. He became chief electrician to the Electrical Power Storage Company, whose employment he left, desiring to go into business for himself as a consulting engineer.

The Police Telegraph System.—Since the riots which took place in the West-end and the meetings of the unemployed in Trafalgar-square the attention of the authorities has been directed to the perfection and extension of the police telegraph system throughout the metropolis. The result has been that during the last few months London has been intersected by a network of wires for the special use of the metropolitan police, and under the present conditions the concentration of a large body of police officers in any part of London on the shortest notice would be a comparatively easy matter. The system has been carried out on an extensive scale. The central police offices are also connected by either telegraph or telephone with the Fire Brigade stations, the War Office, the Home Office, the House of Commons, and the House of Lords, as well as with the private residences of the superior officers. In addition to these extensions, in case of emergency a message handed in at any postal telegraph office by a police officer is to take precedence of any others.

Electric Soldering and Welding.—Since the first successful trials of the Bernados system of electric welding, various disadvantages have begun to make themselves apparent. A German engineer, G. Kamienski, in the *Chemische Zeitung*, gives some particulars with reference to the process. The high temperature of the electric arc is not only very harmful to the eyes, but, it is stated, affects the skin of the face, peeling off the surface skin, and sometimes even causing wounds. The dark glasses hitherto used are too heavy and too dark, and occasionally it is necessary, in order to see clearly the progress of the work, to take them off, with great danger to the eyes. The silk masks which have been tried are unpractical, and also obstruct the breathing. The great luminosity of the arc besides, though not noticeably hot at a short distance, evidently affects the nerves in the manner of sunstroke. A curious feeling is noticed by bystanders at the nape of the neck, which renders them giddy and uncomfortable: and persons who have already suffered from an attack of sunstroke are threatened with a renewal of the symptoms under the glare of the arc.

The Noises of an Engine.—Every steam-engine has certain well-defined sounds in action, which we call noises for want of a better term, and it is upon them and their continuance that an engineer depends for assurance that all is going well. So soon as the sequence or continuity of certain sounds is interrupted, the engineer hurries

into the engine-room to see what is amiss. Curiously enough, compound engines and modern systems, triple and quadruple expansion engines, and high pressures have greatly affected the method of judging whether all is going well or not. "Modern engines play all sorts of tunes," said an engineer to us lately, "and it bothered me greatly to get used to it for a while. Everything would be going well and apparently in harmony for an hour or so, when suddenly the tune would change and another strike up from some cause or another that I have never yet been able to find out, but since I have discovered that it makes no difference in the action of the machine itself I don't bother about it, although it is very annoying." This peculiarity refers to marine engines chiefly, but it may also to stationary engines on the same system, and it is one of the innovations which engineers have to become accustomed to.—*American Engineer.*

Legal.—The plaintiffs in the action of Morgan *v.* Prichett were two ladies, the owners of two houses in Hanway-place, Oxford-street, which are let in flats to weekly tenants, and two of their tenants. The defendants are Messrs. Prichett, who supply, from premises adjoining, electric light to the neighbourhood. The plaintiffs complain that the engines and dynamos of the defendants have been so worked as to produce a nuisance to the tenants, who all occupy the premises as dwellings, by reason of the noise and vibration. The plaintiffs seek an injunction to restrain the defendants from working their machines so as to be a nuisance. The action was now brought on on notice for an interlocutory injunction. There was some conflict of evidence, but the parties were agreed that on a certain occasion, on the evening of the 14th ult., when representatives of both sides were present on the plaintiffs' premises, the works were being carried on so that no substantial nuisance existed. It was stated, in answer to the judge, by counsel for the defendants, that there was record in the defendants' office that their tension meter indicated at that time a resistance of from 100 to 105 volts, and that of the two steam-engines employed by the defendants the smaller was governed to work at, and did on that occasion work at, the speed of 180 revolutions a minute, and the larger one at the speed of 120 revolutions a minute; and he offered to give an undertaking on behalf of the defendants to keep the working within those limits till the trial. His lordship said that one of the defendants' witnesses, cognisant of the matter, must make an affidavit as to the conditions of the working during the three-quarters of an hour in question, and the defendants would undertake to work within the limits of such conditions.

Langham Hotel.—The largest installation hitherto lighted from a central station in England has just been lighted up at the Langham Hotel, Portland-place. This hotel, which is one of the largest in London, is now practically lighted throughout with electric light, the total number of lamps being 1,600, and a further 100 are still to be lighted in the top floors. The current is supplied from the Grosvenor Gallery, the main primary wires entering a separate fire-proof converter-room outside the building in a courtyard of the basement. This room contains five large converters, with their separate fuses, and the secondary cables are run in several groups, of about 200 lights each, to the various departments. The wiring and fittings have been carried out by Messrs. Verity Brothers, of Regent-street, with Mr. J. H. Cundle, 121, Cannon-street, as consulting electrician. The whole of the wiring is practically surface wiring, and fuses are put to all pendants. In the coffee-room the pendants are combination electroliers, with gas jets above and electric lights below, handsomely wrought and gilt decorated work, with iced shades, two ten-light and two six-light electroliers to each large room. The passages are fitted with similar iced shades, each with a socket switch, and the ladies' room and private sitting-rooms have movable standard lamps. The dining-room has a long row of pendants, with large frosted bells, each containing three lamps, which are run two in series, one lamp in each series in the next pendant. Long, neat, mahogany boxes, glass covered, enclose the switches, which are Verity's patent sudden-break tap switches, together with the corresponding double-pole fuses, on china bases, with metal plug fuses. The whole of the work is conveniently arranged, and the size of the installation is a striking proof of the manner in which distribution from central stations is progressing in London.

E.P.S. Accumulators.—Great strides in the development and general efficiency of accumulators have been made lately by the Electrical Power Storage Company. Batteries hitherto capable of yielding 30 amperes discharge for ten hours now yield 45 amperes with the same weight of material, an improvement which is equal to a saving of 50 per cent. in the cost. The Hammersmith omnibuses are now lighted with electric light supplied by special small box accumulators placed under the drivers' seats. Fifty or sixty of these have been in use some time, and the number will be shortly increased to 200. The Omnibus Company have a small gas-engine and dynamos at their Hammersmith shed, to charge the accumulators every night for use next morning. Medical batteries, for use at the various London hospitals, and for private physicians, are also in great demand; these are supplied ready charged by the company, who send for them to be recharged. They have also brought out a stronger and more compact form of battery for traction work, and there seems to be considerable activity promised in this direction, judging by the number of traction Syndicates stirring. The promised development in storage systems advocated for the B.T. system of distribution from central stations will open fields for supply of accumulators of as much larger type than those at present in use as a modern gasometer is larger than a tin cistern. The Electrical Power Storage Company will be able to tackle these requirements as they arise, and at the present moment are able to supply batteries with plates the size of a dining-room table, having a capacity of 800-900 lamps for 10 hours. Their licensees in all parts of the world are extremely busy, especially in America, and we notice that, with repect to the far-famed Julien battery, the American owners of the patent are bringing an action-at-law with reference to the infringement of their patents.

New Types of Storage Cells.—Details of new types of accumulators are arriving from all parts of the world. The wonderful effect of science in utilising waste products, now so noticeable with our friends and rivals the gas companies, lately culminating in the production of sugar, in the form of saccharine, from the once despised coal-tar, and which for the electrician has evolved the reversible or storage cell from the electrical waste product "polarisation," is destined in time to absorb the *raison d'être* of gas and coal tar combined at any rate in their original capacity of house lighting. We invite attention to the detailed description we give elsewhere of the copper accumulator of Messrs

Commelin, Desmazure, and Baillehache, about which we gave a report a week or two ago, with reference to their performance at a test trial with a screw launch at Havre. These cells are now made in a commercial form, but the chief objection to them seems to be the high electro-motive force (1·2 volts) in charging, against the discharging potential of 0·75 only. The lasting power of these cells is also not stated. In Spain, we hear of a new type of accumulator giving greatly increased charge and accelerated speed of discharge with the same weight of material, and although particulars are withheld, there is evidently great activity in various fields to bring to perfection this means of accumulating electrical energy. In Germany, in Hagen, Westphalia, Messrs. Büsche and Müller have just erected a large accumulator factory for the production of a new type of accumulator, the invention of Messrs. Tudor Fréres. Nothing has, up to now, been published with reference to the experiment of the inventors, who have for the last eight years been diligently studying the subject, and have been able to introduce, it is stated, some very important improvements. In the Tudor accumulator the oxide is crystalised in a hard structure upon an underlying lead plate, and is not liable to scale ; the wear and tear by use is almost entirely obviated. The factory will be able to turn out plates in very large quantities, and in a few months will be in a position to supply sets of accumulators with elements of 2,000 ampere-hours capacity, with a rate discharge of 500 amperes. This firm has received a large order for accumulators for the State Theatre at Darmstadt, for which they have given a five years' guarantee.

The Julien Electric Railway.—We have received the following particulars from the Julien Company, of New York. It is now some eighteen months ago since the Julien Electric Company, of New York, obtained from Brussels a storage battery electric car, and put it in service on the streets of New York City. It has been in use on Mr. Vanderbilt's road, running from Eighty-fifth-street and Madison-avenue to City Hall, for about a year, and has given such satisfaction that Mr. Vanderbilt, the president of the New York and Harlem Railroad Company, has made a contract with the Julien Electric Company to place ten electric cars in service on their road forthwith. To that end, the Julien Electric Company are now installing an electric station at Eighty-fifth-street and Madison-avenue with sufficient generating machinery to run the ten cars. The station is nearly finished, as are the cars also, and the system will be in operation about the end of June. The station has two 75 h.p. tubular boilers and two 75 h.p. straight line engines, and two Weston dynamos of the capacity of 300 volts and 85 amperes each. The batteries for the cars are inserted in and removed from the cars by means of a shifting device, which is run by an electric motor. Sufficient batteries for the ten cars are arranged in tiers on either side of the pit over which the car is run, in a way to best subserve economy of space. The cars are 18ft. long. The car body is mounted on two four-wheeled trucks, each truck carrying a 12 h.p. motor, Julien type. Chain-gearing is used ; the car body is pivoted on the trucks, and in this way will describe with ease the very sharp curves to be found in American street railways. The car carries 120 cells of the Julien battery, arranged 60 on either side of the car; each cell has a capacity of two volts and 120 ampere-hours ; they are coupled in series or in parallel by means of the Julien regulator; they are run in series most of the time, thus economising the expenditure of energy much more than when run in parallel. The cars are to be elegantly fitted up, and to be far superior in interior decoration and finish to any street-car hitherto used in America. They will be run from the Grand Central Depot, at Forty-second-street and Fourth-avenue, down town to the Post-office and back. The street railway companies of America are awaiting with great interest the result of this installation ; if it is successful, as we have every reason to hope, electric traction by storage battery will become a great industry in the United States.

New Edition of the Phœnix Rules.—The thirteenth edition of the Phœnix Fire Office rules is now issued, the large number of copies of the twelfth edition being completely exhausted. In the new edition, Mr. Musgrave Heaphy has embodied still further improvements in minor matters, such as cut-outs, and to deal with modern developments of high-tension currents for charging in central station lighting by the battery or B.T. system. The recurring sentence, allowing exceptions under certain conditions by permission of the inspector, found at the end of several of the rules, and which was objected to at the recent discussion, has been removed from those positions, and a note is inserted at the end of the rules, in these words :—" No departure from any of these rules will be allowed, unless permission is given by the inspector from the Fire Office." With regard to the question which has been actively discussed, as to the danger of multiplication of cut-outs, the rule now stands in the way. After stating that, as a general rule, when a branch is led off any conductor, a fusible wire must be inserted near the junction, which should fuse at 50 per cent. above the safe capacity of the wire, or 100 per cent. above the normal when this is below the safe capacity—the rule goes on to say :—" If, however, a branch is already protected by 'cut-outs' on the mains, or on a superior branch, then it may not be necessary to again protect it by other cut-outs, unless required to do so by the inspector of the fire office. It is as well to protect all positive and negative principal branches by fusible cut-outs. This must be done when transformers, accumulators, or primary batteries are used ; also when small branches are taken directly off the mains. . . . . When lights are grouped, as upon electroliers, &c., the small wires to each light cannot always have cut-outs. Care should be taken, however, that the last controlling cut-out carries as small an amount of current as practicable, and that it will act before the smallest wire runs any risk of getting unduly heated." The rule with regard to accumulators and high tension currents is as follows :—" When high tension currents are used from a central station (or other place) to charge accumulators, and secondary house circuits having a current of lower potential than that of the primary circuit are taken from the accumulators, then it would be preferable if the secondary conductors were provided with a device or arrangement by means of which their connection with the accumulators during the time these latter were being charged would be prevented. A current having an electromotive force of 500 volts or upwards, will be considered as as a high tension current for this purpose." The bringing of these rules in this prompt and reasonable manner up to date will still further increase the regard with which they are held, and their general usefulness. The significant passage is still to be seen in the preface that " notwithstanding the number of years these rules have been in use, not a single fire has yet occurred from any electrical installation which has been placed up in compliance with them."

THE BRUSH TRANSFORMER SYSTEM.

Mordey's Alternate Current Dynamo and Transformer.

The first types of dynamos on a practical scale were alternate current machines, then came a period when continuous current machines only were fashionable, and now

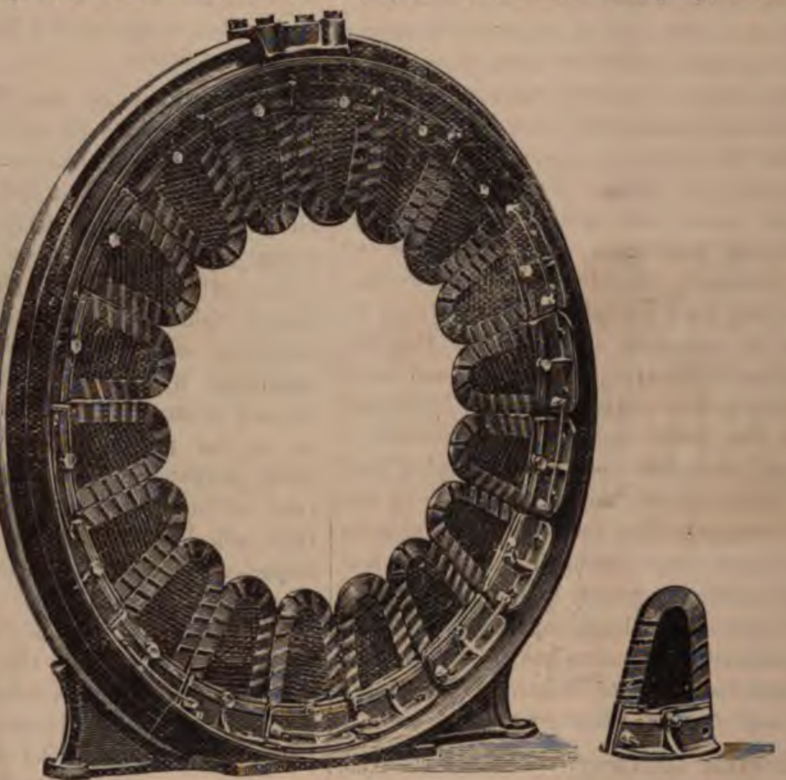


Fig. 1.—Armature. Mordey Alternator.

again we have a reversion of feeling towards alternate current systems. Undoubtedly, the reason for this is the introduction of the transformer, and the adaptability of the combined apparatus for practical work. Without venturing

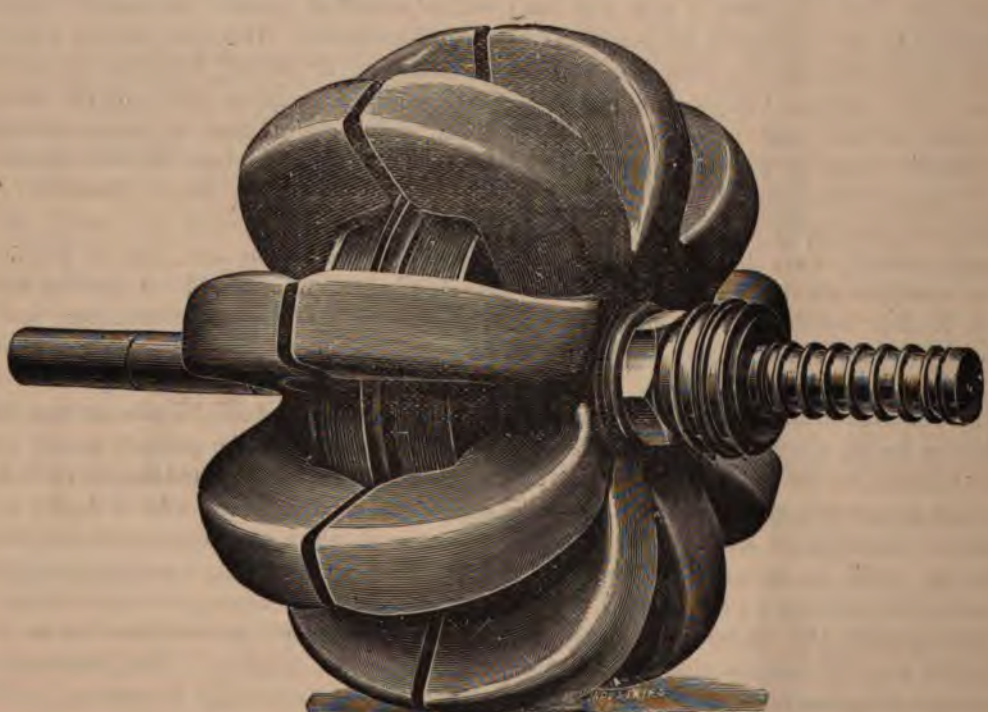


Fig. 2.—Field. Mordey Alternator.

to be guided by American practice, many engineers have been impressed with the value of the transformer from its use in the Grosvenor Gallery installation, and believe it the intermediary between direct lighting from the machine and lighting by means of storage. Other engineers as eminent and as practical refuse to believe in any intermediary, and have pinned their faith upon storage. Whatever may be the ultimate evolutionary effect, we have to deal with carefully-designed apparatus and schemes in both directions. The latest addition to alternate current dynamos is that designed by Mr. W. M. Mordey, of the Anglo-American Brush Company, in which the armature is stationary, and the principle of the iron-clad field has been adopted for the first time in alternate current machines so far as English constructors are concerned. The machine illustrated is intended to give an output of 35,000 to 40,000 watts, with a terminal potential of 2,000 volts at a speed of 650 revolutions per minute.

The armature, Fig. 1, consists of coils of insulated copper ribbon, $\frac{7}{16}$in. wide, wound on cores of non-conducting

material. The supporting cores are of porcelain, and each coil is bolted at the broad end, between two brackets, the ends of the conductor being brought out through porcelain insulators. The brackets are bolted to a gun-metal ring, which for convenience of manufacture and repair is made in halves, the two parts being fastened together at the bottom and to the bed plate, and at the top by a special casting. The coils are thus rigidly and securely held in position by metal supports, which in no part come between the poles, and are, in fact, almost entirely out of the magnetic field. German silver is used for the brackets and bolts, because its high resistance assists in preventing local currents. A single armature coil is shown in the illustration, from which it will without difficulty be seen how the armature is built up. The coils in this case are connected in series, because an high E.M.F. is required ; but any other combination can be obtained, the connections being regulated by the voltage or current required. It will be seen that the designer has carefully considered the important subject of repairs, and that the construction adopted allows not only of a single coil of the armature being quickly removed and replaced, but a half or the whole of the armature can be easily removed. In the machine illustrated the exciting coils have a smaller diameter than the armature, and are wholly within it, and all the poles on the one side of the armature are north poles, those on the other side being south poles, the usual plan being to have these poles alternate. Mr. Mordey, by his plan, reduces the E.M.F. with a given field and speed to one-half, but avoids magnetic leakage and economises copper.

The field-magnet, Fig. 2, consists of a single electro-magnet made as follows : a short wrought-iron cylinder, through the axis of which the shaft passes, forms the core, and is wound with a single coil of exciting wire, the ends of which are brought to two insulated gun-metal collectors. The exciting current is supplied by a small Victoria dynamo, by means of two brushes rubbing against the collecting rings, though other means may be employed for this purpose. Against each end of the above-mentioned cylinder is placed a cast-iron piece of peculiar form. Each casting has a number of arms—nine in the machine illustrated—which radiate from the shaft and central part of the casting, and then bend over, forming nine pole pieces on each side of the armature. These arms, as will be seen, approach each other from opposite sides, and in the gap between, the armature is held, the entire field-magnet revolving with the shaft upon which it is held. This form of field-magnet is simple, and a single exciting coil suffices for a machine of any size, speed, or number of alternations.

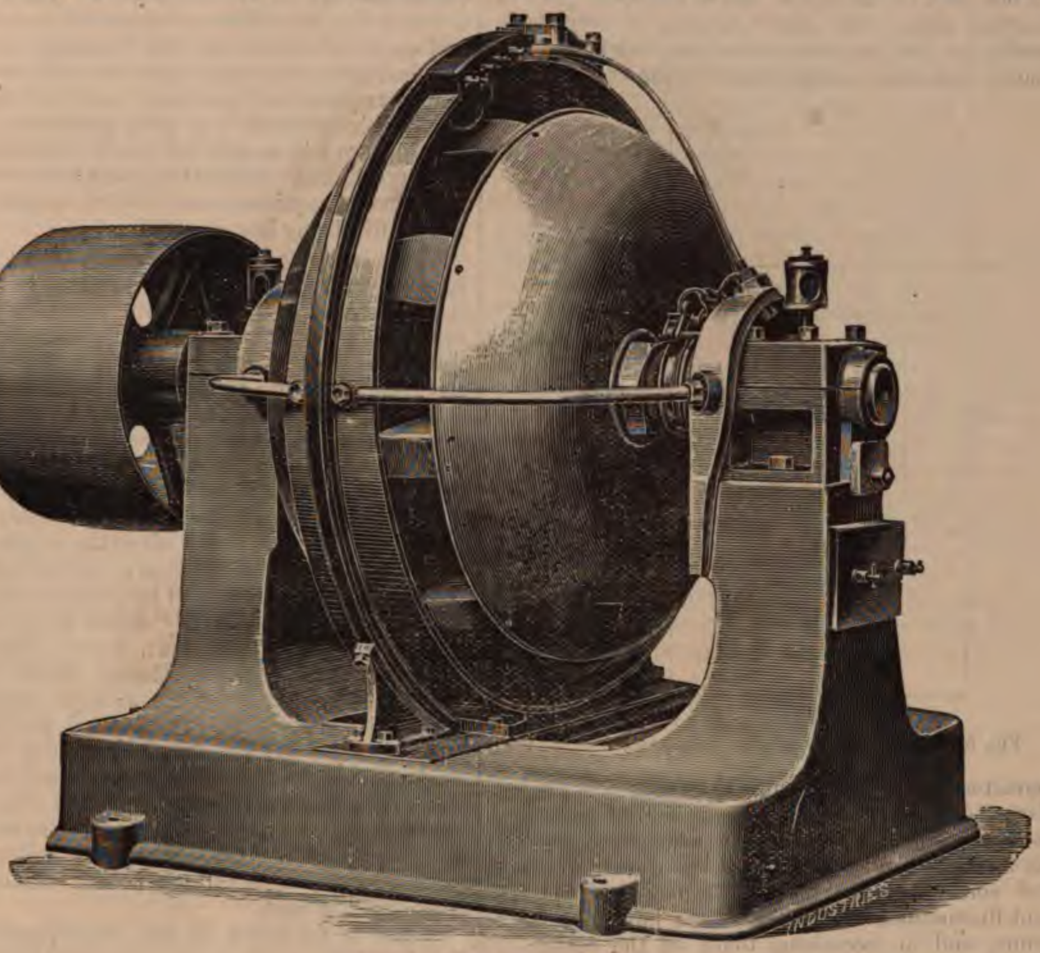


FIG. 3.—Mordey Alternator.

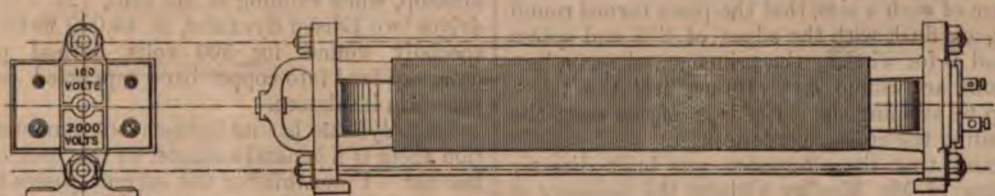


FIG. 4.—End and Side view, Mordey Transformer.

By revolving the field-magnet, instead of the more delicate armature, safety and steadiness of running are secured, the heavy magnet acting as an excellent fly-wheel, and effectually neutralising any pulsations due to irregularity in the stroke of the engine. This is a point of some importance where slow-speed engines are used. Further, as the parts revolving at the highest velocity are simple solid iron masses of the strongest description not subject to heating, and having no copper wire to expand and fly out, the electrical and mechanical considerations which, in ordinary dynamos, usually renders low-speed advisable, do

not here apply. The armature being stationary, the coils have to be supported only with a view to resisting the drag of the field. This renders insulation a matter of comparative simplicity, and is of great importance in high-tension work. The alternator is shown in its complete form in Fig. 3. The field-magnet is almost entirely hidden by sheet metal covers, which have for their object the prevention of air disturbance by the horns. The armature terminals, which are not seen in the figure, are at the upper part of the supporting ring. The thrust-bearing is adjustable longitudinally for the purpose of enabling the field to be placed exactly symmetrical with regard to the armature.

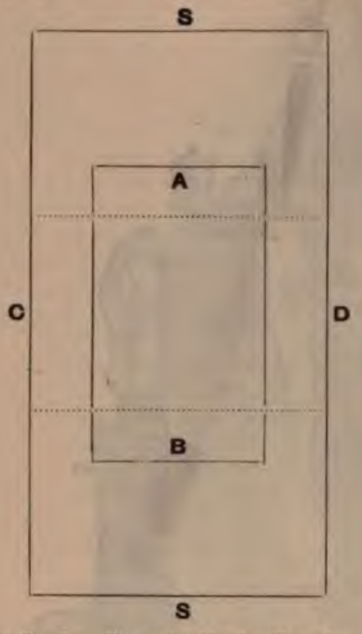


FIG. 5.—Iron Plates for Mordey Transformer.

The characteristics of the machine show that it is almost self-regulating. It is, therefore, not considered necessary or desirable, except under special circumstances, to provide other than a simple hand regulation at the dynamo for the purpose of controlling the potential difference. Sudden and violent fluctuations of the lights are impossible with this machine, and an occasional touch of the resistance regulator as the load comes on or off meets all practical requirements. It is only in the case of machines whose potential curve is a rapidly falling one that it is necessary to resort to automatic control. There is no doubt that by avoiding the use of additional apparatus of this sort the chances of temporary interruption are reduced.

The total weight of the machine is 2 tons 1cwt., of which just over half is made up of the armature and field-magnets.

With this machine is intended to be used the Mordey transformer, shown in Fig. 4. This transformer is neatly and simply made. A suitable sized sheet of iron, S S, Fig. 5, is taken, and a rectangular piece, A B, stamped out of the centre of such a size, that the piece turned round the edges, C D, are flush with the edges of S S, and spaces are left at A and B for winding the primary and secondary coil. These coils are wound on a frame, and the transformer built up by slipping the outer iron pieces over the wire, and threading the cross pieces through.

We understand that the alternator was built directly from the designs of Mr. Mordey without the necessity of experimental work to evolve the machine, thus showing that the progress made in this branch of mechanical engineering has during the past five years been very great. We design a steam-engine and build it straight away, the same, as we have said, is now being done with dynamos. Two of these machines are to be erected at the Oxford-street electric lighting station.

RICHMOND UNION TRAMWAYS.

From time to time our readers have been made acquainted with the construction of the electric tramways in England, such as those of Holroyd Smith at Blackpool, and, more recently, the Bessbrook and Newry tramway in Ireland, besides which we may mention the Brighton tramway and that at Giant's Causeway. The total mileage, however, of English tramways is comparatively small, while in America great progress has been made. The Richmond Union road, U.S., which we propose now to describe, has a length itself of about twelve miles. It runs a very irregular course through the principal parts of the city. The mileage of the streets passed through is about nine miles. The central section is a double line for a distance of about two miles, a part being laid on paved streets and the remaining on macadam. In our last issue we dealt with the differences of tractive power required on gradients and curves. Part of this line has sharp curves and steep gradients. In one portion the rails are laid in four curves of respectively 27, 30, 40, and 50ft. radius. Altogether, there are no less than twenty-nine curves, requiring bent rails, the majority being of sharp radius, five being less than 30ft.

There is one section of almost continual ascent for about 5,600ft., with gradients varying from 3 to 7 per cent., and another stretch of 1,900ft., with gradients varying from 3 to 10 per cent. The experience of our American contemporaries is, that it is far cheaper to construct a good line at the first rather than to construct a cheaper line. Among other suggestions, all curves should be bound in and paved. They should likewise have two guard rails, because it is much easier to steer a car by its rear wheels, by holding them in place, than by allowing them to crowd the inner rail, and force the forward wheel to climb the outer one. In dry weather it is found advisable to grease the grooved rails. Another point which is to be carefully considered is the character of switch used for sidings and cross-overs. If drop switches are used, they should be of such character as to allow the car to come down easily. This line has been fitted up by the Sprague Electric Motor Company. The generating station is at about equal distance from the extremities of the line. The station includes three brick buildings, the main building containing the engines and dynamos, being separated from the other two by a covered way. The cars are kept in one of the other buildings, and the third is the boiler-room. The latter contains a battery of three cylindrical return tubular boilers of the latest pattern, mounted on a Jarvis patent furnace, their capacity being 125 h.p. each.

Water is furnished by two Worthington steam-pumps. From the pumps the water passes through a feed-water-heater, where it is heated from 150deg. to 200deg. Fahrenheit, after which it goes through a filter. The boilers feed into one main-feed steam-pipe, which in turn leads to a separator, a large iron cylinder into which the steam passes, the water falling to the bottom, and the dry steam being carried off at the top. From the boiler-room, both the steam and exhaust pipes run into an underground trench to the engine-room. This trench is of brick, the walls and bottom being 8in. thick, and after the pipes were put in place they were completely covered in with mineral wool, and the trenches covered with planking. The engines, of which there are three, are of the Armington-Sims high-speed type, and develop, when running at full load, 125 h.p. Each engine drives two Edison dynamos, of 40,000 watts capacity each, specially wound for 500 volts normal pressure. The dynamos feed into copper bars, supported on the walls by porcelain insulators.

Each dynamo has its independent ammeter, and in addition there is a general ammeter at the end of the positive bus bar. From this bar the current passes to four special snap switches, each switch being connected, through a three-plug safety switch block, to one of the feeders supplying current to the main line wire. These four-feeder wires tap into the line wire at four different points, thus maintaining the pressure approximately equal all along the line. At the ends of one of the feeders in the central station, pressure indicators are to be attached which will indicate the voltage at the junction of the feeders with the main current wire.

The engine-room is brilliantly lighted by eight hanging electroliers, each of which has five incandescent lamps. A switch-board at one end of the room furnishes an independent control for each group of lamps. All wires in the room are well insulated, and in addition are held off from

the walls and ceilings by porcelain insulators. The engines and dynamos are fenced in by polished brass railings; brass oil screens and drop-cups are placed wherever necessary; on the floors are brass-tipped mattings; and, in fact, the room is kept as neat and clean as a well-appointed office, and it is not going too far to state that the station equipment has no superior in the world.

The electric circuit consists of two parts—the overhead and the ground circuits, each being of compound character. Along the kerb stones, at distances of 125ft. are 30ft. poles, inserted into the ground a distance of 5ft. Great difficulty was experienced at first on account of the clayey character of the soil, and it became necessary at the corners to put in very heavy poles, which were embedded in concrete and stone, to prevent settling out of place after heavy rains. These poles carry the main circuit, which extends throughout the entire length of the road, and is a copper wire $\frac{3}{16}$in. in diameter. This is called the main conductor, for on it depends the operation of the road in case of accident or repairs to the contact wire.

This latter is termed the "working conductor," and is of hard drawn copper of the same size as the main conductor, and is carried over the centre of the track, at a distance of about eighteen feet from the ground, on insulators supported by span-wires running across from pole to pole, and provided with additional insulators at their ends. The whole structure is very light looking, and at night cannot be seen. It hardly seems possible that it can be the medium of transmission of nearly 400 h.p. of electrical energy distributed over twelve miles of track, on which at any one time forty cars can be in operation. This working conductor is of the same size no matter whether one or a hundred cars are to be operated, or whether one or twenty miles of track are to be covered; but it is connected to the main conductor at intervals of 500 feet by short branch wires, the whole forming a ladder-like circuit.

This main conductor is itself supplied at four widely separately points by feeders which come from the main supply at the central station. Without the use of these feeders, which can also be reinforced if necessary, the size and cost of the overhead conductors would be very largely increased. The curves are formed of a series of short chords, which approximate the central line of curvature.

The current is taken from this working conductor by a light ornamental structure on top of the car. This consists of a low skeleton framework, which carries an adjustable swivelling trunnion, having at its upper end a jaw in which is suspended a counter-balanced trolley pole, having at its extension a grooved wheel making running flexible contact on the under side of the working conductor. The flexibility of this arrangement is very great, it being able to follow with perfect facility variations of the trolley wire 2ft. or 3ft. in either horizontal or vertical direction at any speed and around any curve. When getting at the end of the track, this trolley trunnion is swung around so as to trend in a proper direction abaft the centre of the car. It is impossible for it to pull the trolley wire down, and if off the line can be replaced from the car quickly and easily in the darkest night. From the trolley the current passes through a protected wire to two switches, one at each end of the car, whence, after whatever commutation is necessary, it goes to the motor circuits, and thence to the wheel frame.

The return circuit is through the track, and thence by both metallic and ground circuits to the station. Each section of rail is joined to a copper ground wire, which runs throughout the length of the road underneath or alongside the stringer-pieces. At intervals of 500 feet this ground wire is connected to an earth plate, and at seven points widely distributed. These ground plates are supplemented by heavy iron pipes sunk into iron ore or 12in. water wells about 25 feet deep. The ground wire is connected to the station, and there is also a main ground connection made there in a thirty-foot well through a large sink plate. Some modifications of the overhead system are now being made which will make it impossible for any accident to one section of the line to disable the remainder; will enable the different sections to be operated independently, and, in case of a fire which may necessitate the the blocking or temporary disabling of one part of the line, will allow this section of the line to be cut out of action either automatically or at will.

Each car is fitted with a duplicate and very powerful motor equipment. This is carried entirely beneath the car body, is very compact, out of sight, and necessitates no radial change in the construction of the car. The body had to be stiffened a little, and 3in. steel axles put in. One of the great objections which has been met with in applying motors, whether steam, electrical, or of any other character, to the propulsion of street railways, has been the difficulty of getting sufficient track adhesion to operate the car under all conditions of track, loads and grades. Especially was this objection true in Richmond, where it was manifest that no application of a motor system could be fully successful unless the entire weight of the car and its contents was made available for traction.

One of the manifest reasons is, of course, the slippery character of the track under many conditions. Another thing should also be noted, and that is that it is almost impossible in practice to cast all wheels exactly the same circumference, or at least so that the path described by the line of contact shall be the same for all wheels. Moreover, on curves the wheels are all travelling over paths of different lengths. Theoretically, the wheels should be independently driven, but since this is not possible it follows that the next best thing is to drive each pair of wheels independently. It is a fact which admits of no dispute that there are conditions of track which will not admit of a car being driven from one pair of wheels only, and this difficulty is often augmented by the fact that if one pair of wheels only is used they will sometimes be leading, sometimes following; on heavy grades, too, with one platform reserved for the driver, there is a very serious displacement of the centre of gravity, and there may be very much more weight upon one pair of wheels than on the other. The whole experience in Richmond has been to emphasise the value of independently driven axles.

To accomplish this, each motor is centred upon its axle; and to allow the required freedom, and at the same time to preserve perfect parallelism in the meshing of the gears, and also for taking part of the motor off the body of the axle and to throw it on to the journals, one end of the motor is supported near the centre of the car by double compression springs playing upon a loosely suspended bolt which is supported from a cross girder in the bottom of the car.

The motors are then, so to speak, weighed or flexibly supported from the car body, and the motion of the armature is transmitted to the axles through a novel method of spring gearing, of compact form and great strength, so that whenever the axles are in motion there is a spring touch of the pinions upon the gears. Barring friction, a single pound pressure exerted in either direction would lift or depress the motor a slight amount, and no matter how sudden the strain, whether because of a variation of load or speed, or a reversal of direction or rotation, it is impossible to strip the gears unless the ultimate strain exceeds the strength of the iron, the pressure on the gears always being a progressive one. The motor armature makes nearly 12 revolutions to each revolution of the car axle, but by an ingenious automatic lock switch an electrical mechanical gearing can be effected with double the tortional effort for a given current and cuts down the speed.

The motors, although in one sense independent, are connected with duplicate switches at either end of the car, which afford simultaneous control of both machines. These motors, which are of normal capacity of $7\frac{1}{2}$ h.p. each, can for a short time work up to 25 h.p., and are capable of producing a momentary tractive effort of over 3,000lb.

The cars can be run at widely different speeds, varying from the slowest crawl to twelve or more miles per hour. They can be started and stopped without the use of brakes in the space of three or four inches, and when making the normal running speed can, in an emergency, be stopped and reversed without brakes within less than a quarter of a car-length. The control over the car seems marvellous, for one sees little or nothing save an almost imperceptible movement of the hand of the motor-man; and the starting, although prompt, is gradual, and without shock or jar.

Emergencies sometimes bring out qualities of motors

which are unexpected, or which, at least, if counted on, are rarely ever brought into play. On one occasion a man was descending a 6 per cent. grade with a heavy load, when his brake-chain parted. Seeing a sharp curve right ahead of him, which he knew he would leave if he struck it at the speed he was running, he instantly reversed his machines and brought his car to a standstill, and on the rest of his trip handled his machines entirely with the motors. On another occasion a man passing from behind one car directly in front of another, was struck and knocked down by the dashboard. Although the car was moving at a lively gait, the machines were reversed, and the wheels stopped within a foot of the man. By any other method of propulsion he would have been killed. Frequently, on a 10 per cent. grade, with a loaded car, the brakes have been thrown off, the machines reversed, the car stopped, and started backward up-hill within less than one-half of its length—a test of the most remarkable severity.

In noting the wonderful control of the car, one is struck at the remarkable character of the traction, and cannot help wondering where it comes from. Unquestionably, it is in a large measure due to the fact that every pound of weight is available for traction, and that the two wheels, being independently driven, can take their own speed, and each pair get the best grip.

Another thing to be noted, where the ground circuit is used, is the increase of traction due to the passage of the current from the wheels into the rails. Exactly what molecular action takes place has not been ascertained. It may be simply heating at the contact surface; but the fact remains that the traction is very largely increased. The magnetic condition of the wheels and tracks also has some function in this increase of traction. The wheels and axles are magnetised by the method of motor construction and mounting, and also by the passage of the current through them. The tracks are likewise magnetised by the current passing through them, and also by the rolling contact of the wheels. Yet, admitting all these aids, the results have been extraordinary.

Sixteen-foot closed cars carrying picked loads of fifty-five to sixty passengers, and having a total weight of 15,000lb., are operated on the 10 per cent. grade, often with a slippery and slimy rail, and on 27ft. curves, without the use of sand or extra help.

These same grades and curves have been ascended also without sand after one of the worst sleet storms that has visited this section for years. Various tests under the most unfavourable conditions have been made, cars often being required to cut their way through clay, snow, and ice when the tracks were out of sight. No severer test could have been made, and the power and tractive effort developed have exceeded the most sanguine expectations. Cars have often been stopped and started on the heaviest grades, and in the sharpest curves. One motor has propelled two cars around sharp curves and up 6 per cent. grades. One car has pushed another of greater weight around the sharpest curves and up 7 and 8 per cent. grades, both straight and combined.

During the three and a-half months' operation, although there have been troubles, and changes have been made while the cars are running commercially, no car has been pulled a foot by animal power; if any accident has occurred to a motor the car has gone along with one machine, oftentimes with heavy loads and on heavy grades, or in some cases has gone home in company with another car. One hundred and twenty men who did not know the difference between a motor and a handsaw have been broken into handling these cars; oftentimes with remarkably short training. In fact, more than 120, because a number had been dismissed for various reasons.

Some things peculiar to the electric car may here be mentioned.

A marked advantage of it in a crowded street, in addition to the power of control, is the fact that all the horse room is saved, and the car consequently is able to be worked with much narrower limits.

Where grade work is encountered, an electric car can not only make double the speed on the up grades, but can run on down grades at a much higher safe rate of speed than horses can be driven ahead of a car.

A car has none of the lurching motion which is experienced in cable transmission, and is so marked on the Philadelphia road, and it has in a marked degree less of the oscillation caused by the pull of the horses on the draw-bar.

The layer of mud of which the dash-boards of a street car is decorated from the hoofs of the horses is, it is almost needless to say, absent on an electric car.

The lighting, for which each car with its five lights require about half a horse-power, is very brilliant, and free from the odour attending the use of oil.

The figures which follow, being based upon an actual service increasing from eight to thirty cars, and extending over a period of four months, under the most trying circumstances and at the most critical and care-requiring period of the enterprise's existence, give street-railway men the most careful and liberal estimate of every possible expense attending the operation of the road which is any way dependent upon its electrical features. The operating expenses are given under two heads; first, the central station operating expenses, and second, the road operating expenses, the two constituting the total cost of motive power. These are given in detail, and they will probably be found to cover every expense, although in some small ways the distribution of these expenses may be found to be changed by several months longer running. The fuel and other incidental expenses of the station are from the engineers' record, and checked by the readings of the electrical instruments.

The central station expenses are as follows:

58 $\frac{42}{100}$cwt. coal at 10 cents	$5.84	
113 $\frac{70}{100}$cwt. screenings at 7 cents	7.96	
5 pints cylinder oil at 75 cents per gallon	.47	
5 pints dynamo oil at 30 cents per gallon	.18	
3lb. waste at 10 cents	.30	
Water at current rates	3.00	
Fuel, &c.		$17.75
1 day engineer	$3.00	
1 night engineer	2.25	
4 firemen	6.00	
1 cleaner	1.50	
2 dynamo men	3.50	
1 electrician	4.00	
Labour		$20.25
Lighting		.50
Depreciation: on dynamos 3 per cent., and repairs		1.50
On engine boilers 10 per cent.		4.38
Total central station expenses		$44.03

or $1.48 per car making 80 miles.

In estimating the road expenses, more than liberal allowance is made; but in a new enterprise it is safe to err on this side, rather than attempt to claim for a sy-tem advantages which will not in practice be borne out. The expenses are then as follows:—

Oil, grease and waste	$1.50	
Brushes	4.00	
Trolleys	2.40	
Material		$7.50
3 mechanics and one helper for thoroughly overhauling motors once a week, making repairs, adjusting brakes, &c.	7.90	
4 inspectors, two days and two nights, for oiling machines, and looking after brushes	7.50	
2 night inspectors to thoroughly inspect motors after cars are laid up and see that all bolts, nuts, and connections are tight and that everything is in good working order for the morning run	4.00	
1 winder and helper for making any repairs which may be necessary and any testing which is required	3.50	
2 linemen	5.00	
1 carpenter to fix windows, sashes, switches, signs, &c.	2.00	
Labour		$29.90
Depreciation { on car work at 15 per cent.	18.00	
Depreciation { on line work at 10 per cent.	4.00	
Depreciation		$22.00
Total road operating expenses		59.40

or $1.98 per car making 80 miles.

The total motive power expenses both in the central station and out on the road would not then exceed $3.46 per car, making eighty miles, or $4\frac{32}{100}$ cents. per car mile, and this includes everything except the executive and salary

experses, taxes and insurance, and is only *40 per cent.* of the cost of operation by horses with the same number of cars.

But the showing is even better than this, for another fact is to be noticed, and it is an important one from an economical point of view. Twenty cars on duty for about eighteen hours make a mileage of from 1,500 to 1,800 per day, and if it were not for the fact that the schedule requires them to operate part of the time on a single track with insufficient turnouts, they could make 1,800 or 1,900 steadily, this notwithstanding the fact that the speed is limited by regulations. Many of the cars often run over 100 miles. This same mileage and intervals made by twenty electric cars could not under the circumstances be made by anything less than twenty-five horse cars of the same size, and the electric cars probably carry in the aggregate just as many passengers. It follows, that to get the same service with horses, not only would the number of cars have to be increased, but likewise the number of horses, conductors, and drivers. The same mileage performed by horses with these cars and grades would require a stable equipment of not less than 275 to 300 horses.

A good idea of the operation of the system may be obtained from the following weekly table taken from the records of the railway company :—

Week ending	No. of cars put out for regular service.	Average number of cars out per day.	Miles per week.	Average miles per day.	Average miles per car per day.	Passengers per week.	Average passengers per day.
Feb. 8..	72	10·3	2,632	376	36·5	18,764	2,680
,, 15..	48	6·9	1,211	173	25·2	6,688	956
,, 22..	77	1·0	2,604	372	33·6	16,504	2,358
,, 29..	91	13·0	4,039	577	44·4	21,944	3,135
Mar. 7..	94	13·7	5,047	721	52·6	25,063	3,580
,, 14 .	86	12·3	5,313	759	61·8	20,897	2,985
,, 21..	99	14·1	6,916	988	69·9	30,357	4,337
,, 28..	113	16·1	8,621	1,232	76·3	27,076	3,868
Apl. 4..	118	16·9	8,351	1,193	70·8	28,260	4,037
,, 11..	133	19·0	10,089	1,441	75·9	36,683	5,240
,, 18..	133	19·0	10,583	1,512	79·6	40,090	5,727
,, 25..	135	19·3	10,895	1,557	80·7	39,040	5,577
May 2..	137	19·6	11,309	1,616	82·4	45,350	6,479
,, 9..	140	20·0	10,832	1,548	77·4	51,648	7,378

UNDERGROUND ELECTRICAL CONDUCTORS IN EUROPE AND AMERICA.*

BY PROF. G. W. PLYMPTON.

The problems of construction of underground systems of electrical conduction will have been solved when the telephone and the arc light systems are both buried under our streets without impairing the efficiency or durability of either.

By this I mean that all the difficulties encountered in burying conductors are involved in converting telephone and arc light from *aerial* to *underground* systems. Telegraph lines and systems of incandescent lighting present fewer difficulties in the process of burying, and none of a kind not met with in dealing with the systems first mentioned.

The telephone problem is substantially solved. Some details only remain to be settled, among which may be mentioned the best size of conductor, the most serviceable insulation and the maximum distance of effective service for either grounded or metallic circuits.

In Brooklyn the general plan adopted is that of a conduit divided into ducts through which cables containing from sixty to one hundred wires are drawn. The material of the conduit is for the most part creosoted wood About ten miles of this is already in use in our city, and about four and a-half miles of the Dorsett concrete conduit. For the extensions of the underground systems for the present year only creosoted timber is to be used.

Among the lessons learned from our experience are :—1. That in creosoted conduits the use of cables covered with kerite, or any similar rubber or gutta-percha compound, must be avoided. 2. That in the so-called lead-covered cables the use of pure lead is also to be avoided, as it is slowly converted into a porous and friable lead carbonate. An alloy of lead with 5 or 6 per cent. of tin seems to resist the destructive action. 3. That the conducting wire first used is too small for satisfactory telephone service. The difficulties of induction and retardation led to complaints as soon as 4,000ft. or 5,000ft. of underground wire was put in service. The cables that are now being put in are made up of wires whose cross section is greater by one-third than that of the first wire, and they are protected by twice the thickness of insulation.

I mention the above conclusions as having been drawn from our own experience in Brooklyn.

In commencing our work, we gathered such information as could be gleaned from localities where solutions of the problem had already been attempted. The impression so largely prevailed that in Europe all telephone and telegraph conductors were underground, that our Board decided that a personal inspection of European systems should be made by one of our number. The duty devolved upon me. The result of my inquiry has been published in the scientific papers.

I will briefly refer to a few of the incidents. (Prof. Plympton here gave an epitome of the third annual report of Brooklyn Subway Commission, which embodied his observations).

In regard to the burial of the arc light wires, I can only say that no method yet tried seems certain of success. Most of them certainly insure the destruction of the underground conductors in from one to three years. But I have no doubt that a solution of the problem will soon be reached, although the system will be kept apart from the telephone and telegraph subway.

It does not seem likely that arc light conductors will be allowed in the same conduit with telephone wires, nor will they be distributed from the same manholes.

In saying that, I believe that a solution of the problem will soon be found. I do not mean to assert that casualties like that recently recorded of a man in the Bowery, who lost his life by grasping the naked wire close to an arc lamp, can be prevented by any system of burying wires. To prevent such *accidents*—if that is the term to be used—the arc lights must be buried with the wires.

All past experience teaches us to proceed cautiously. Nothing can now permanently check the growth of the telephone, the telegraph, or the electric light. They have become necessities of our civilisation, and any hasty or ill-advised enforcement of the law to convert all aërial to underground systems which should result in serious injury to them, would prove the surest way to perpetuate the nuisances of overhead wires and poles in the streets.

* Read before the American Institute of Electrical Engineers, May 16, 1888.

CORRESPONDENCE.

THUNDERSTORMS AND LIGHTNING ACCIDENTS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—As the season of thunderstorms and lightning accidents is now approaching, I hope you will kindly allow me to make known through your columns the fact that in the interest of science the Institute of Medical Electricity is very desirous of obtaining authentic information concerning lightning accidents, whether fatal or otherwise. I should, therefore, esteem it a favour if some of the many friends of humanity among your readers will assist us to investigate these phenomena by sending me such particulars of accidents of this nature, as they may have personal or reliable knowledge of, as soon after they occur as possible.

Of course, electrical and physiological details are what we most require, but reliable general information is often very valuable, and will be gratefully received.—Yours, &c.,

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

THE BRIGHTON ELECTRIC RAILWAY.

Was it not Whewell who first wrote about the martyrs of science? Probably, however, there is a class of men fated to suffer more from their fellow-men than those who are pioneers of pure science, and this is the pioneers of applied science. Archimedes fell under the sword of a common soldier; Galileo fell into the hands of the Inquisition. The former lost his life; the latter quibbled, and saved it. In these latter days it is not the life of a pioneer which is at stake; it is his money. The uneducated mob attempted the ruin of Arkwright. We had almost added that an educated mob has ruined a pioneer of electrical engineering. Many readers of the *Telegraph* interested in electrical progress were no doubt astonished to read the other day that another attempt was to be made to do away with the Brighton electric railway. A special meeting of the Town Council was convened for last Wednesday to consider a recommendation of the Works Committee that the proprietor of the electric railway should be required to remove his plant. It is quite time someone indulged in a little plain speaking on this and cognate subjects. A good deal of opposition has been encountered by electric light contractors to the erection of machine rooms, because of the noise of running machinery. There is some reason for this, and dwellers in private houses may not be blamed for describing a nuisance by its proper name, and demanding that every effort should be made to reduce the noise to a minimum. The continued opposition at Brighton is not of this kind—it has no legitimate origin, and proceeds from those whose real object is hidden. Many of our readers do not know Brighton, but they may know that it is almost a suburb of London—a suburb by the sea. Of late years a large number of wealthy people luxuriate in a house at Brighton, and would reserve the whole place to themselves. They hate excursion trains and excursionists as the proverbial devil hates holy water. They would make Brighton a second Belgrave-square, where corduroy should be unknown, and no one permitted to visit who did not put on a dress suit for dinner. Hence anything that tends to popularise the place and attract visitors is an eyesore to those whose aim is exclusiveness. We do know Brighton, and maintain that we are as well able to judge of the allegations made against the electric railway as the *Daily Telegraph*. The *Telegraph* tells us that "the ground is wanted for the new works on the Madeira-road." We say distinctly it is not so, and that the contemplated improvements are not on the ground of the railway at all. The Madeira-road is a *cul-de-sac*, and never will be an aristocratic resort, like the Hove end of the Promenade. The sea wall, from thirty to fifty feet high, bounds one side of the road, on the other is the shingle, and along the edge of

the shingle the electric railway runs. The only interference the railway has committed is the removal of a few capstans half-a-dozen yards. The ordinary roadway has been improved, by being widened and levelled. The fact is that the opponents of the railroad think any stick good enough to beat a dog with. They have been consistent; and though for a while the supporters of the railway were the stronger, the strain has been too continuous, and the supporters are disheartened. Years ago, when "electricity" was the "coming wonder," Mr. Volk, of Brighton, a well-known electrician, had the idea that electricity was applicable as a motive power, and he obtained permission to make this experimental railway. It was the first in England, almost the first in Europe. Electricity was the unknown force then with which the world was to be revolutionised. The few did not want the revolution, and preferred to remain "as you were." Notwithstanding the opposition, the line was laid and operated successfully. Mr. Volk was a working electrician, believing in his work, and not only laboured, but put his whole savings into the line. It was successful, and everything promised fair. Nature, however, in the shape of storms, shattered the line and did hundreds of pounds worth of damage. The opposition, too, had not been idle, but persistently attacked the line at every opportunity; instituted legal proceedings, and ultimately the losses, one way and another, brought the owner into the bankruptcy court. Some friends made strenuous efforts to counteract the opposition, but in the end, from all we hear, the result will inevitably be the destruction of the Brighton line. For the moment, however, a respite has been given, the result of the special meeting of the Town Council being that it is not deemed expedient to reopen the question of the removal of the railway until the improvements on the Madeira-road lately sanctioned are completed. It might be explained also that the residences above the Madeira-road are wholly out of sight of the railway, so that it forms no bad feature in the land, or rather seascape, as seen from drawing-room windows. The machinery, too, is in what may be termed a cave excavated in the hill side, so that it creates no nuisance.

Such, briefly, is the history of the first electric railway in England. Promoted and constructed by the energy of one man, satisfactorily worked against all difficulties brought forward by pride, prejudice, and ignorance, it remains in the unsatisfactory condition we have described. Is it too much to hope that the supporters of the railway will not hesitate to continue their efforts, and obtain some arrangement whereby the founders of this line may be relieved from the worries and anxieties of these constant attacks? It is admitted that the line has been and is an attraction to the eastern end of the town, and we contend that whatever proves an attraction to the town is beneficial to the business portion of the town, and this is far more important than that a few moneyed men should have the exclusive right to a mile of beach and a sheltered promenade.

ALTERNATE-CURRENT MOTORS.

Some weeks ago, quoting from a New York contemporary, we were able to direct attention to M. Nikola Tesla's work in connection with the use of alternate currents and motors. At the late meeting of the American Institute of Electrical Engineers, M. Tesla read a paper upon the subject, amply illustrated and descriptive of the work upon which he has been engaged. It is too soon and the materials at command are too scanty to enable a definite conclusion to be arrived at, but whatever further information may bring forth, there is no mistaking the fact that this paper will mark an era in the progress of electrical engineering. The thoughts of many inventors have been directed to the design of alternate current motors, practical men have pointed out the link wanted in the apparatus supplied them, and the supporters of the continuous current system have had their hands considerably strengthened from the fact that no apparatus was discovered whereby energy could be distributed by means of alternate current machines. The advocates of alternate currents pointed out that could such apparatus be devised it would probably lead to a reduction in prices for machines, and decrease the cost of maintenance and the probability of breakdowns. M. Tesla's work, be it crude and impracticable, or fairly perfect and practical, will enforce the dictum that a want has only to be felt, and sooner or later it will be supplied. We have never sided with those who professed such apparatus to be impossible. The greater number of mechanical and continuously rotary movements are obtained by the application of opposite forces at different periods. The maidservant draws a pail of water from the bottom of a well by alternately pushing and pulling on the handle of the windlass. The locomotive goes continuously forward, by reason of the expansive force of steam applied first in one direction then in the opposite direction, and it was doing an injustice to the inventive talent of the world to believe that the push and pull of electricity could not be used to obtain continuous motion in any desired direction. The views expressed by M. Tesla in his paper will be carefully studied, and, without doubt, there will follow many improvements in the direction he has pointed out.

How Science Advances.—"He who wishes to keep abreast with the march of science to-day, must leave the college and go to the workship, and into the dark corners of private laboratories, for investigators rarely have time to write, so that text-books are years behind the science itself."—*Prof. Elisha Gray.*

THE COPPER ACCUMULATOR.

Messrs. Commelin, Desmazures, and Baillehache have been engaged for some considerable time upon the construction of a new type of accumulator which has attracted a large amount of attention. The Commelin accumulator is based upon a peculiar property of metals hitherto little heeded.

If a metallic powder is compressed under a pressure of 500 or 1,000 atmospheres, a metal is obtained of a perfectly solid and homogeneous nature, but porous. Exteriorily, it presents the characteristics of cast metals, and differs only in being considerably lower in density, and in this state the new metal absorbs nascent oxygen with extraordinary facility. The zinc-copper-potass element designed by Faraday polarises after it has been a short time at work; it is able to give a constant current only for a short period, owing to the small quantity of oxide with which the ordinary sheet copper of commerce is covered. When this element is exhausted—that is to say, when the potass is saturated with zinc—the Faraday cell consists of zinc, copper, and zincate of potass. In attempting to regenerate or renew it by electrolysis, some of the zinc is precipitated on the remaining zinc, and oxygen is carried to the copper plate, which is oxidised superficially. But the oxide of copper formed under these conditions, being soluble in the potass, copper will be precipitated on the positive element at the same time as the zinc, and will cause local currents, so that the regenerated cell will give only very moderate results.

The substitution of a plate of porous copper for the copper plate of the exhausted Faraday cell, will give an element whose regeneration can be effected in a slightly more satisfactory manner. The copper is dissolved less quickly in the potass, and is deposited less rapidly on the positive zinc, but still the final result is not much better. If, however, the porous copper is covered with parchment paper, the regeneration is effected without difficulty; all the dissolved zinc is deposited, the porous copper absorbs an equivalent quantity of oxygen, and an apparatus is obtained which can be indefinitely regenerated. This is the principle of the Commelin copper accumulator.

For negative electrodes in charging, it has plates of tinned sheet iron, and for positive electrodes plates of pure porous copper, obtained by compression, at 500 to 1,000 atmospheres, from powdered copper obtained by electrolysis. The positive electrodes, enveloped in parchment paper, are separated from the negatives by tubes of glass, or preferably by strips of vulcanite, and the whole is immersed in a box of white metal containing zincate of potass or soda, according to the application. A battery of these accumulators has been constructed to furnish the motive power for a screw launch for the French Navy at Havre.

The accumulator used in these experiments contained six negative electrodes and five positive. Their usual height is 56 centimetres (22in.), their width 12·5 cm. (5in.). The total surface of the positives is 70 square centimetres. The white metal box is 70 centimetres high (27½in.), 15 centimetres (5⅞in.) wide, and 8 centimetres (3⅛in.) deep. The quantity of zincate of potass is 6 litres (1¼ gallons) per cell, and the weight is 18 kilos. (14lb.).

The zincate of potash in the marine type contains 150 grammes of zinc per litre, which is 900 grammes for 6 litres. This corresponds to a capacity of 733 ampere-hours, when all the zinc is precipitated. When the cell is newly mounted, the porous copper plates, which remain exposed to the air for a certain time, become oxidised, and, if charged under these conditions, the action is unsatisfactory. It is indispensable, in order to put them in a good state for use, to submit them at first to a reducing current —*i.e.*, only in a contrary direction to the charging current.

During the operation of charging, the zinc is deposited on the tin plates, and the oxygen is carried to the porous plate without the least development of gas. The oxygen, arriving at the positive, combines with the copper, or possibly is only occluded. If it combined with the copper, it would only be able to give a sub-oxide. As a matter of fact, the cells being charged, if the positives are removed their aspect is seen to be unaltered, and have kept their original red colour, which fully indicates that they do not contain cupric-oxide, which is black. Even admitting the formation of cupric-oxide during the charge, this compound, being soluble in potass (?), the solution being in intimate contact by reason of the parchment covering with an excess of metallic copper, will be restored to the state of protoxide: $Cu\,O + Cu = Cu_2O$. Moreover, this reaction must always be produced, for the porous plates of the marine type can only receive 800 to 900 ampere-hours, that is to say, one-third of that which they could receive if the copper was transformed into cupric-oxide. There is, therefore, always at the positive an excess of metallic copper; therefore an absolute impossibility of the formation of cupric-oxide.

Some curious phenomena are observed when charging this accumulator. At the beginning the level of the liquid rises, and continues to rise progressively until the moment of stopping the charging. When, on the contrary, the cell is discharged, the opposite phenomena occur: the level of the liquid gradually falls, and does not return to its original point until the accumulator is entirely discharged. These facts seem to prove that the oxygen must really be occluded. If it combined with the copper, the rise of the liquid would not take place at first—the level would not be raised until after the copper were combined. Then only the oxygen filling the pores of the plate would increase the volume of the liquid. At the discharge, on the contrary, the oxygen ought to disappear immediately, and the liquid regain its normal height some minutes after closing the circuit. It is found that this does not take place until the cell is entirely discharged.

The rate of charge of the marine type of cell is about 30 to 35 amperes, with a maximum electromotive force of 1·2 volts; time about twenty-four to thirty hours. The rate of discharge in the trials with the electric launch was 80 to 90 amperes, with a difference of potential of 0·75 to 0·80 volts. According to the recent experiments made by M. Krebs with a motor driven by this battery, an efficiency is obtained for quantity of 86·5 per cent., and of energy of 65 per cent. A rate of charge of 100 amperes has been used. It is a matter of important progress to notice that the duration of charging will be considerably shortened. It can be thus charged in seven or eight hours.

It should be mentioned that M. de Lalande has laid claim to priority for this invention. M. Lalande reminds us that he also has a copper battery, which is reversible, and equally renewable by electrolysis. A specification of this character has indeed been included in M. Lalande's patent. But to this the inventors object that M. Lalande's battery is derived from that of Faraday, and in the same manner as that type, is not able to be renewed by electrolysis, because in charging cupric-oxide is formed, which is soluble in potass (?), and therefore there is precipitation of copper upon the negative. In addition, the renewal cannot be practicable with electrolysis, because the authors propose the following proceeding at the beginning; the zincate of potass taken from the elements is treated with sulphuretted hydrogen, which gives a sulphate of zinc useful for paints; the reduced copper is exposed to the air to be retransformed to cupric-oxide. Though it may be stated that a battery is theoretically renewable by electrolysis, there does not exist one in which this is practicable. In the battery, the chemical reaction which produces the current is prepared by the chemist, and it is quite ready to act at the moment the circuit is closed. In the accumulator, on the other hand, this reaction is prepared by a current, and, up to the present, it is only possible to renew the reactions produced by the current itself.—*Electricité.*

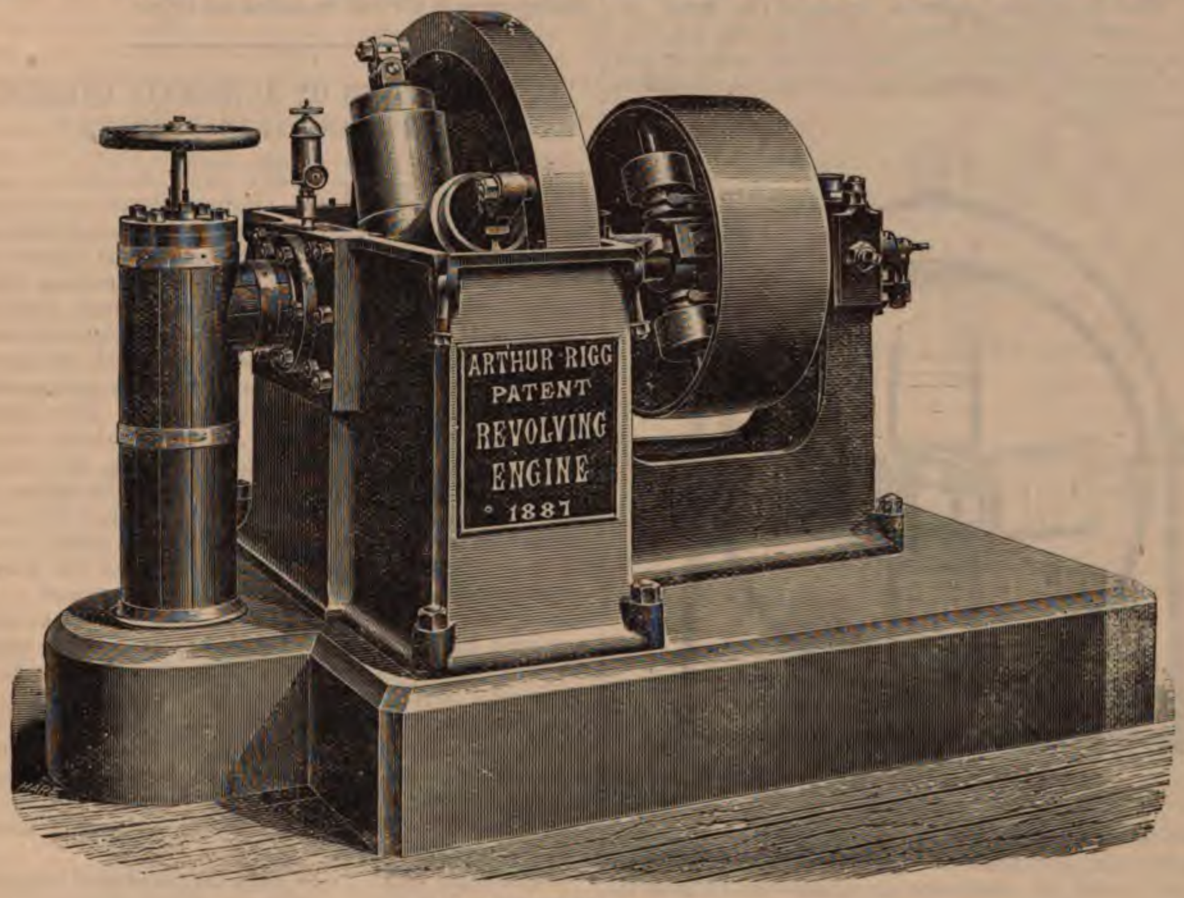
[NOTE.—We have ventured to query the statement, made in two places by our contemporary, in investigating the theory of this accumulator, that cupric-oxide is soluble in potass.—ED. *E. E.*]

RIGG'S ENGINE.

In our issue of May 18th we described the "Mather" dynamo, which is based upon the revolving engine of Mr. A. Rigg. That this is the case will be seen from the accompanying illustration and description of this engine, which is intended to be a combination of the most recent improve-

ments directed towards accurate driving and the utmost economy in fuel. It is the outcome of the inventor's experience gained, since 1872, with engines of the usual reciprocating type running at high speeds, and its arrangements have been perfected after a critical examination of the most successful modern engines in England and America made during the autumn of 1884, after the visit of the British Association to Montreal.

This invention initiates a system of construction free altogether from reciprocations, which are inseparable from all other engines having pistons and cylinders; it also provides the means of running without any irregular dynamical strains. In slow-moving engines the power absorbed for accelerating their reciprocating parts is considered to bear but a small proportion to the total amount, so that early rates of expansion can be used with a low average pressure; but this is not the case with quick-running engines, where the power required for acceleration may reach 20 per cent. or more of the total work done, unless a high average pressure be maintained. It is mainly from this cause that high-speed engines, as at present constructed, which, while removing all the evils of reciprocation, possesses none of those objections which have caused the practical failure of other attempts in the same direction. The illustration and diagram show that this engine consists of four cylinders, all revolving freely and independently upon a common central stud. Their pistons are all connected to corresponding crank pins, equidistant apart on the face of a wheel, which also turns freely round, and no other connection exists as between cylinders and pistons except that already mentioned. The centres of cylinders and wheels are parallel to each other, but yet at a certain distance apart, and thus, while both revolve together, the pistons, which are carried by the wheel, are seen to reciprocate in relation to the cylinders, although both are partaking of a simple independent revolution. This relative movement answers exactly the same purpose as the reciprocation of an ordinary piston, only that as the cylinders are truly balanced among themselves, and the pistons are balanced each to each, a perfect balance is maintained throughout the revolutions. The cylinders are weighed against each other during construction, and so also are the pistons; therefore the machinery



Rigg's Patent Revolving Engine.

do not employ an early cut-off, nor produce those economical results which are commonly found with larger engines of equal power. The assumption that power taken up during the first half of a stroke can be recovered towards its conclusion assumes that there is something to be gained by compression of exhaust to fill capacious passages; whereas this operation is but an expedient for receiving the impact of a steam hammer, which would produce a violent concussion if permitted to expend its full force upon the crank pin.*

Having investigated these problems with much care, and having enjoyed opportunities of putting high-speed theories into practice, the conclusion was reached that these evils were inherent in all existing engines, and that no real remedy could be found so long as reciprocation of the piston formed an essential feature in their design.

This conclusion revealed new difficulties, but it led finally to the invention of the revolving engine in a new form,

runs in true equilibrium with a dynamic balance that is practically perfect, and there are no reciprocations; and, as a proof of the correctness of these deductions, these engines have been driven over 2,000 revolutions per minute without any vibration, producing only a loud hum by so high a velocity. They run quite quietly at more reasonable speeds, and with careful adjustment are practically silent. Referring again to the design of the engine, it is easy to see that admission of pressure while the pistons move out, and opening of exhaust during their return, causes a revolution to take place; and, as there are four cylinders, no dead centres exist, and the engine will start itself perfectly well from whatever position it may have come to rest. It follows that there is a tangential driving effect of great uniformity, and no maximum with recurrent absolute zero, such as happens with single cylinder engines of ordinary types. Even under so sensitive a test as driving a dynamo, it is found that incandescent light can be obtained of an absolute steadiness without any fly-wheel beyond the engine itself, and there is no other motor that can compare with these results except a turbine.

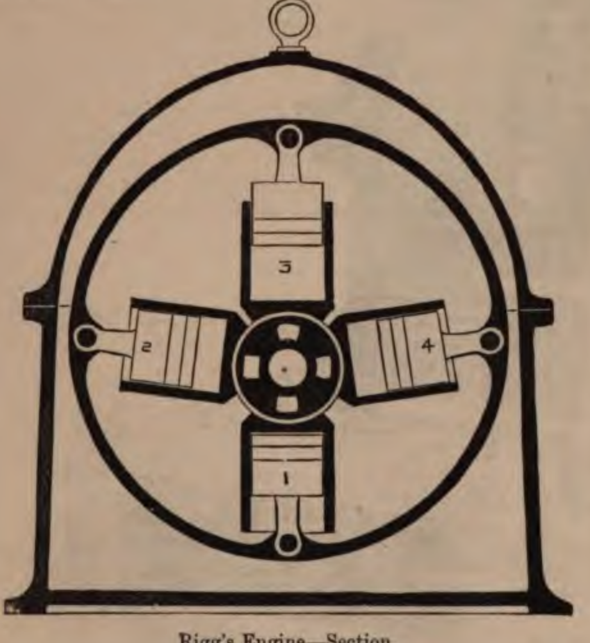
Such angular changes in velocity as do occur in this

* The influences of reciprocation, and the limits beyond which high-speed engines should not be driven, are fully discussed in Mr. Rigg's "Practical Treatise on the Steam Engine," 1878, and in his paper on "Obscure Influences of Reciprocation in High-Speed Engines," published in the *Transactions* of the S ciety of Engineers for 1886. See *The Engineer* of 4th June, 1886.

engine balance each other exactly, because power absorbed in accelerating one cylinder while moving from 3 to 1 is being restored at the same time by the retardation of another cylinder moving from 1 to 3, and thus a complete cycle of equilibrium is established, and as no dynamic strains interfere with the regularity of driving, its smoothness excels that of reciprocating engines as usually constructed.

The cylinders are enclosed in a bed with removable cover, so that all vital parts are protected, and lubrication facilitated. In the engraving the cover is removed.

Four separate steam ports are provided, and are presented in turn before a fixed inlet and exhaust, so that steam enters each cylinder to force the piston out, and passes away during its retreat, and there is a constant driving power, so the engine will start from any position. Regulation as to speed is accomplished by a powerful and sensitive governor enclosed within the main driving pulley, and its movements are conveyed by levers and rods to a balanced expansion valve, which causes no change in the exhaust, however the point where steam is cut off may vary. This expansion valve is arranged to cover or uncover a number of small steam ports set in one angular direction around the fixed valve face, so that more or less steam is admitted as required, and the rate of expansion varied accordingly.



Rigg's Engine—Section.

These revolving engines are conveniently compounded by placing two simple engines on opposite ends of the same shaft, and under all conditions experience shows them to be as durable and working with economy in fuel equal to the best larger engines of corresponding power.

For marine or winding engines the valve setting has the peculiarity that either ahead or astern the exhaust remains unaltered, while the rate of expansion is caused to vary; and rods or handles to move the valve for starting, stopping, or regulating the expansion ahead or astern can be carried to the bridge, and a marine engine of any power, and of this type, can be driven by the officer there, and this is an advantage of value, particularly for war ships or cruisers. The same construction renders these engines well adapted for use as winding-engines for collieries and mines. They also start themselves directly steam is turned on, and one special peculiarity is that they are found to run silently, and are eminently suited for places where this peculiarity will be thoroughly appreciated. As there are no unbalanced parts, the engine runs noiselessly, and without any vibration that can be communicated to the ship. It can also be arranged for twin screws, or to be run at a high speed, and under the latter condition is eminently suitable for driving the guide blade propeller, invented by the author now just twenty years ago.

Hydraulic engines are made on the same general principle, differing from steam engines in the valve setting, which ensures a full supply of water up to the termination of every stroke, and in the mode of governing. This is done by changing the positions of the cylinder stud and that of the main shaft; and as this eccentricity determines the stroke just like the radius of a crank determines the stroke of a piston, there is a ready means provided by which this class of hydraulic engine can be governed. A supplementary hydraulic engine is employed to effect the necessary transfer, and the governor has no further duty to perform than to move the valves of this other engines, so that there is no difficulty in governing and maintaining a uniform speed with the advantage of using water pressure just equivalent to the work performed.

These hydraulic engines are eminently suitable for use as domestic motors, driven by the ordinary water main pressure, and performing such laborious work as driving knife-cleaning machines, and they run with perfect uniformity.

They can also be employed for electric lighting purposes, and driven from the mains of the Hydraulic Power Supply Company, or any other source of power.

The largest yet made is used for driving a dynamo producing current for 100 incandescent lights.

A NEW SYSTEM OF ALTERNATE CURRENT MOTORS AND TRANSFORMERS.*

BY NIKOLA TESLA.

In the presence of the existing diversity of opinion regarding the relative merits of the alternate and continuous current systems, great importance is attached to the question whether alternate currents can be successfully utilised in the operation of motors. The transformers, with their numerous advantages, have afforded us a relatively perfect system of distribution, and although, as in all branches of the art, many improvements are desirable, comparatively little remains to be done in this direction. The transmission of power, on the contrary, has been almost entirely confined to the use of continuous currents, and notwithstanding that many efforts have been made to utilise alternate currents for this purpose, they have, up to the present, at least, as far as known, failed to give the result desired. Of the various motors adapted to be used on alternate current circuits the following have been mentioned :—1. A series motor with subdivided field. 2. An alternate current generator having its field excited by continuous currents. 3. Elihu Thomson's motor. 4. A combined alternate and continuous current motor. Two more motors of this kind have suggested themselves to me. 1. A motor with one of its circuits in series with a transformer and the other in the secondary of the transformer. 2. A motor having its armature circuit connected to the generator and the field coils closed upon themselves. These, however, I mention only incidentally.

The subject which I now have the pleasure of bringing to your notice is a novel system of electric distribution and transmission of power by means of alternate currents, affording peculiar advantages, particularly in the way of motors, which I am confident will at once establish the superior adaptability of these currents to the transmission of power, and will show that many results heretofore unattainable can be reached by their use; results which are very much desired in the practical operation of such systems, and which cannot be accomplished by means of continuous currents.

Before going into a detailed description of this system, I think it necessary to make a few remarks with reference to certain conditions existing in continuous current generators and motors, which, although generally known, are frequently disregarded.

In our dynamo machines, it is well known, we generate alternate currents which we direct by means of a commutator, a complicated device and, it may be justly said, the source of most of the troubles experienced in the operation of the machines. Now, the currents so directed cannot be utilised in the motor, but they must—again by means of a similar unreliable device—be reconverted into their original state of alternate currents. The function of

* Read before the American Institute of Electrical Engineers, May 16.

the commutator is entirely external, and in no way does it affect the external working of the machines. In reality, therefore, all machines are alternate current machines, the currents appearing as continuous only in the external circuit during their transit from generator to motor. In view simply of this fact, alternate currents would commend themselves as a more direct application of electrical energy, and the employment of continuous currents would only be justified if we had dynamos which would primarily generate, and motors which would be directly actuated by such currents.

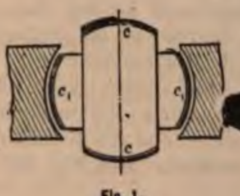


Fig. 1.

Fig. 1a.

But the operation of the commutator on a motor is twofold; firstly, it reverses the currents through the motor, and secondly, it effects, automatically, a progressive shifting of the poles of one of its magnetic constituents. Assuming, therefore, that both of the useless operations in the system—that is to say, the directing of the alternate currents on the generator and reversing the direct currents on the motor—be eliminated, it would still be necessary, in order to cause a rotation of the motor, to produce a progressive shifting of the poles of one of its elements, and the question presented itself, How to perform this operation by the direct action of alternate currents? I will now proceed to show how this result was accomplished.

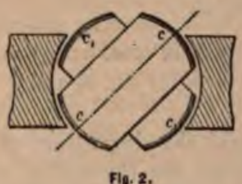


Fig. 2.

Fig. 2a.

In the first experiment a drum-armature was provided with two coils at right angles to each other, and the ends of these coils were connected to two pairs of insulated contact rings as usual. A ring was then made of thin insulated plates of sheet iron, and wound with four coils, each two opposite coils being connected together so as to produce free poles on diametrically opposite sides of the ring. The remaining free ends of the coils were then connected to the contact rings of the generator armature so as to form two independent circuits, as indicated in Fig. 9. It may now be seen what results were secured in this combination, and with this view I would refer to the diagrams, Figs. 1 to 8*a*. The field of the generator being independently excited, the rotation of the armature sets up currents

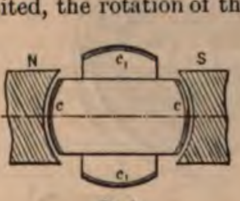


Fig. 3.

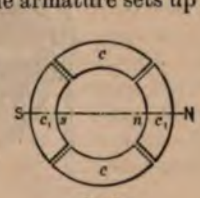


Fig. 3a.

in the coils *c c* varying in strength and direction in the well-known manner. In the position shown in Fig. 1 the current in coil *c* is nil, while coil c_1 is traversed by its maximum current, and the connections may be such that the ring is magnetised by the coils *c c* as indicated by the letters, N S, in Fig. 1*a*, the magnetising effect of the coils *c c* being nil, since these coils are included in the circuit of coil *c*.

In Fig. 2 the armature coils are shown in a more advanced position, one-eighth of one revolution being completed. Fig. 2*a* illustrates the corresponding magnetic condition of the ring. At this moment the coil *c* generates a current of the same direction as previously, but weaker, producing the poles, n_1, s_1, upon the ring; the coil *c* also generates a current of the same direction, and the connections may be such that the coils *c c* produce the poles *n s*, as shown in Fig. 2*a*. The resulting polarity is indicated by the letters N S, and it will be observed that the poles of the ring have been shifted one-eighth of the periphery of the same.

In Fig. 3 the armature has completed one-quarter of one revolution. In this phase the current in coil *c* is a maximum, and of such direction as to produce the poles N S, in Fig. 3*a*, whereas the current in coil c_1 is nil, this coil being at its neutral position. The poles, N S, in Fig.

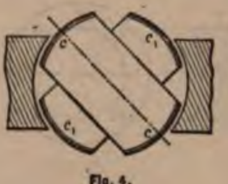


Fig. 4.

Fig. 4a.

3*a* are thus shifted one-quarter of the circumference of the ring.

Fig. 4 shows the coils *c c* in a still more advanced position, the armature having completed three-eighths of one revolution. At that moment the coil *c* still generates a current of the same direction as before, but of less strength, producing the comparatively weaker poles *n s*, in Fig. 4*a*. The current in the coil *c* is of the same strength, but of opposite direction. Its effect is, therefore, to produce upon the ring the poles n_1 and s_1 as indicated, and a polarity N S results, the poles now being shifted three-eighths of the periphery of the ring.

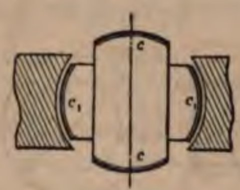


Fig. 5.

Fig. 5a.

In Fig. 5, one-half of one revolution of the armature is completed, and the resulting magnetic condition of the ring is indicated in Fig. 5*a*. Now, the current in coil *c* is nil, while the coil c_1 yields its maximum current, which is of the same direction as previously; the magnetising effect is therefore due to the coils c_1 c_1 alone, and, referring to Fig. 5*a*, it will be observed that the poles, N S, are shifted one-half of the circumference of the ring. During the next half-revolution the operations are repeated, as represented in the Figs. 6 to 8*a*.

A reference to the diagrams will make it clear that during one revolution of the armature the poles of the ring are shifted once around its periphery, and each revolution producing like effects, a rapid whirling of the poles in

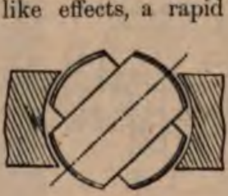


Fig. 6.

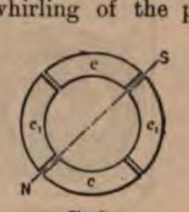


Fig. 6a.

harmony with the rotation of the armature is the result. If the connections of either one of the circuits in the ring are reversed, the shifting of the poles is made to progress in the opposite direction, but the operation is identically the same. Instead of using four wires, with like result, three wires may be used, one forming a common return for both circuits.

This rotation or whirling of the poles manifests itself in a series of curious phenomena. If a delicately pivoted disc of steel or other magnetic metal, Fig. 9, is approached to the ring, it is set in rapid rotation, the direction of rotation varying with the position of the disc. For instance, noting the direction outside of the ring, it will be found that inside the ring it turns in an opposite direction, while it is unaffected if placed in a position symmetrical to the ring.

This is easily explained. Each time that a pole approaches it induces an opposite pole in the nearest point on the disc, and an attraction is produced upon that point. Owing to this, as the pole is shifted further away from the disc a tangential pull is exerted upon the same, and the action being constantly repeated a more or less rapid rotation of the disc is the result. As the pull is exerted mainly upon that part which is nearest to the ring, the rotation outside and inside, or right and left respectively, is in opposite directions. When placed symmetrically to the ring, the pull on opposite sides of the disc being equal, no rotation

Fig. 7.

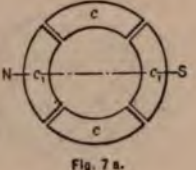


Fig. 7a.

results. The action is based on the magnetic inertia of the iron; for this reason a disc of hard steel is much more affected than a disc of soft iron, the latter being capable of very rapid variations of magnetism. Such a disc has proved to be a very useful instrument in all these investigations, as it has enabled me to detect any irregularity in the action. A curious effect is also produced upon iron filings. By placing some upon a paper, and holding them externally quite close to the ring, they are set in a vibrating motion, remaining in the same place, although the paper may be moved back and forth; but in lifting the paper to a certain height which seems to be dependent on the intensity of the poles and the speed of rotation, they are thrown away in a direction always opposite to the supposed movement of the poles. If a paper with filings is put flat upon the ring


Fig. 8.

Fig. 8a.

and the current turned on suddenly, the existence of a magnetic whirl may be easily observed.

To demonstrate the complete analogy between the ring and a revolving magnet, a strongly energised electro-magnet was rotated by mechanical power, and phenomena identical in every particular to those mentioned above were observed.

Obviously, the rotation of the poles produces corresponding inductive effects, and may be utilised to generate currents in a closed conductor placed within the influence of the poles. For this purpose it is convenient to wind a ring

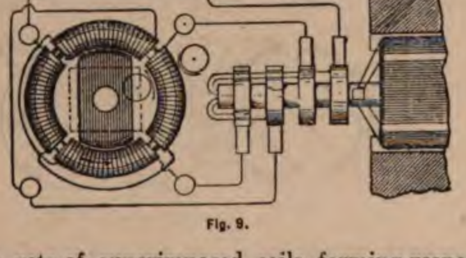


Fig. 9.

with two sets of superimposed coils, forming respectively the primary and secondary circuits. In order to secure the most economical results the magnetic circuit should be completely closed, as shown in Fig. 10, and with this object in view the construction may be modified at will.

The inductive effect exerted upon the secondary coils will be mainly due to the shifting or movement of the magnetic action; but there may also be currents set up in the circuits in consequence of the variations in the intensity of the poles. However, by properly designing the generator and determining the magnetising effect of the primary coils, the latter element may be made to disappear. The intensity of the poles being maintained constant, the action of the apparatus will be perfect, and the same result will be secured as though the shifting were effected by means of a commutator with an infinite number of bars. In such case the theoretical relation between the energising effect of each set of primary coils and their resultant magnetising effect may be expressed by the equation of a circle having its centre coinciding with that of an orthogonal system of axes, and in which the radius represents the resultant and the co-ordinates both of its components. These are then respectively the sine and cosine of the angle, a, between the radius and one of the axes ($o\,x$). Referring to Fig. 11* we have $r^2 = x^2 + y^2$; where $x = r$ cos. a, and $y = r$ sin. a.

Assuming the magnetising effect of each set of coils in the transformer to be proportional to the current—which may be admitted for weak degrees of magnetisation—then $x = \mathrm{K}\,c$ and $y = \mathrm{K}\,c^1$, where K is a constant and c and c^1 the current in both sets of coils respectively. Supposing, further, the field of the generator to be uniform, we have for constant speed $c^1 = \mathrm{K}^1$ sin. a, and $c = \mathrm{K}^1$ sin. $(90^\circ + a) = \mathrm{K}^1$ cos. a, where K^1 is a constant. See Fig. 12.

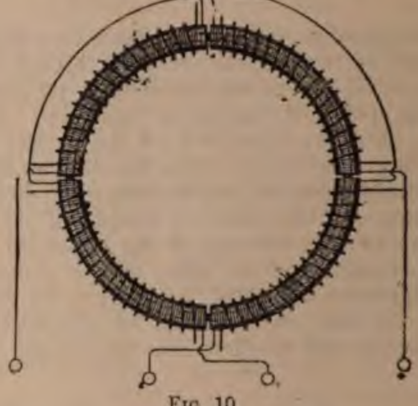


Fig. 10.

Therefore,

$$x = \mathrm{K}\,c = \mathrm{K\,K}^1 \text{ cos. } a;$$
$$y = \mathrm{K}\,c^1 = \mathrm{K\,K}^1 \text{ sin. } a, \text{ and}$$
$$\mathrm{K\,K}^1 = r.$$

That is, for a uniform field the disposition of the two coils at right angles will secure the theoretical result, and the intensity of the shifting poles will be constant. But from $r^2 = x^2 + y^2$ it follows that for $y = 0$, $r = x$; it follows that the joint magnetising effect of both sets of coils should be equal to the effect of one set when at its maximum action. In transformers, and in a certain class of motors, the fluctuation of the poles is not of great importance; but in another class of these motors it is desirable to obtain the theoretical result.

In applying this principle to the construction of motors, two typical forms of motor have been developed. First, a form having a comparatively small rotary effort at the

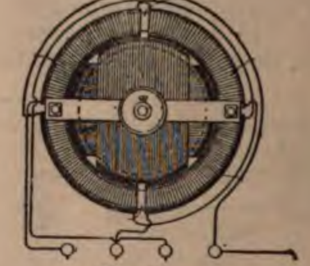


Fig. 14.

start, but maintaining a perfectly uniform speed at all loads, which motor has been termed synchronous. Second, a form possessing a great rotary effort at the start, the speed being dependent on the load.

These motors may be operated in three different ways: 1. By the alternate currents of the source only. 2. By a combined action of these and of induced currents. 3. By the joint action of alternate and continuous currents.

The simplest form of a synchronous motor is obtained by winding a laminated ring provided with pole projections with four coils, and connecting the same in the manner

* By an error of engraver, Figs. 11, 12, and 13 cannot be given. Fortunately Fig. 11 and 12 are simple trigonometrical diagrams which the reader can easily construct from the text—Ed. *E.E.*

before indicated. An iron disc, having a segment cut away on each side, may be used as an armature. Such a motor is shown in Fig. 9. The disc being arranged to rotate freely within the ring in close proximity to the projections, it is evident that as the poles are shifted it will, owing to its tendency to place itself in such a position as to embrace the greatest number of the lines of force, closely follow the movement of the poles, and its motion will be synchronous with that of the armature of the generator—that is, in the peculiar disposition shown in Fig. 9, in which the armature produces by one revolution two current impulses in each of the circuits. It is evident that if, by one revolution of the armature, a greater number of impulses is produced, the speed of the motor will be correspondingly increased. Considering that the attraction exerted upon the disc is greatest when the same is in close proximity to the poles, it follows that such a motor will maintain exactly the same speed at all loads within the limits of its capacity.

To facilitate the starting, the disc may be provided with a coil closed upon itself. The advantage secured by such a coil is evident. On the start, the currents sets up in the coil strongly energise the disc and increase the attraction exerted upon the same by the ring, and currents are generated in the coil as long as the speed of the armature is inferior to that of the poles. Considerable work may be performed by such a motor even if the speed be below normal. The intensity of the poles being constant, no currents will be generated in the coil when the motor is turning at its normal speed.

Instead of closing the coil upon itself, its ends may be connected to two insulated sliding rings, and a continuous current supplied to these from a suitable generator. The proper way to start such a motor is to close the coil upon itself until the normal speed is reached, or nearly so, and then turn on the continuous current. If the disc be very strongly energised by a continuous current, the motor may not be able to start, but if it be weakly energised, or generally so that the magnetising effect of the ring is preponderating, it will start and reach the normal speed. Such a motor will maintain absolutely the same speed at all loads. It has also been found that if the motive power of the generator is not excessive, by checking the motor the speed of the generator is diminished in synchronism with that of the motor. It is characteristic of this form of motor that it cannot be reversed by reversing the continuous current through the coil.

The synchronism of these motors may be demonstrated experimentally in a variety of ways. For this purpose it is best to employ a motor consisting of a stationary field magnet and an armature arranged to rotate within the same, as indicated in Fig. 13. In this case the shifting of the poles of the armature produces a rotation of the latter in the opposite direction. It results therefrom that when the normal speed is reached, the poles of the armature assume fixed position relatively to the field magnet and the same is magnetised by induction, exhibiting a distinct pole on each of the pole pieces. If a piece of soft iron is approached to the field-magnet, it will at the start be attracted with a rapid vibrating motion produced by the reversals of polarity of the magnet; but as the speed of the armature increases the vibrations become less and less frequent, and finally entirely cease. Then the iron is weakly but permanently attracted, showing that the synchronism is reached and the field-magnet energised by induction.

The disc may also be used for the experiment. If held quite close to the armature, it will turn as long as the speed of rotation of the poles exceeds that of the armature; but when the normal speed is reached, or very nearly so, it ceases to rotate and is permanently attracted.

A crude but illustrative experiment is made with an incandescent lamp. Placing the lamp in circuit with the continuous current generator, and in series with the magnet-coil, rapid fluctuations are observed in the light in consequence of the induced currents set up in the coil at the start; the speed increasing, the fluctuations occur at longer intervals, until they entirely disappear, showing that the motor has attained its normal speed.

A telephone receiver affords a most sensitive instrument; when connected to any circuit in the motor the synchronism may be easily detected on the disappearance of the induced currents.

In motors of the synchronous type it is desirable to maintain the quantity of the shifting magnetism constant, especially if the magnets are not properly subdivided.

To obtain a rotary effort in these motors was the subject of long thought. In order to secure this result, it was necessary to make such a disposition that while the poles of one element of the motor are shifted by the alternate currents of the source, the poles produced upon the other elements should always be maintained in the proper relation to the former, irrespective of the speed of the motor. Such a condition exists in a continuous current motor; but in a synchronous motor, such as described, this condition is fulfilled only when the speed is normal.

The object has been attained by placing within the ring a properly subdivided cylindrical iron core wound with several independent coils closed upon themselves. Two coils at right angles are sufficient, as in Fig. 14, but a greater number may be advantageously employed. It results from this disposition that when the poles of the ring are shifted, currents are generated in the closed armature coils. These currents are the most intense at or near the points of the greatest density of the lines of force, and their effect is to produce poles upon the armature at right angles to those of the ring, at least theoretically so; and since this action is entirely independent of the speed—that is, as far as the location of the poles is concerned—a continuous pull is exerted upon the periphery of the armature. In many respects these motors are similar to the continuous current motors. If load is put on, the speed, and also the resistance of the motor, is diminished and more current is made to pass through the energising coils, thus increasing the effect. Upon the load being taken off, the counter-electromotive force increases and less current passes through the primary or energising coils. Without any load the speed is very nearly equal to that of the shifting poles of the field magnet.

It will be found that the rotary effort in these motors fully equals that of the continuous current motors. The effort seems to be greatest when both armature and field-magnet are without any projections; but as in such dispositions the field cannot be very concentrated, probably the best results will be obtained by leaving pole projections on one of the elements only. Generally, it may be stated that the projections diminish the torque and produce a tendency to synchronism.

A characteristic feature of motors of this kind is their capacity of being very rapidly reversed. This follows from the peculiar action of the motor. Suppose the armature to be rotating and the direction of rotation of the poles to be reversed, the apparatus then represents a dynamo machine, the power to drive this machine being the momentum stored up in the armature, and its speed being the sum of the speeds of the armature and the poles. If we now consider that the power to drive such a dynamo would be very nearly proportional to the third power of the speed, for this reason alone the armature should be quickly reversed. But simultaneously with the reversal another element is brought into action; namely, as the movement of the poles with respect to the armature is reversed, the motor acts like a transformer in which the resistance of the secondary circuit would be abnormally diminished by producing in this circuit an additional E.M.F. Owing to these causes the reversal is instantaneous.

If it is desirable to secure a constant speed, and at the same time a certain effort at the start, this result may be easily attained in a variety of ways. For instance, two armatures, one for torque, and the other for synchronism, may be fastened on the same shaft, and any desired preponderance may be given to either one; or an armature may be wound for rotary effort, but a more or less pronounced tendency to synchronism may be given to it by properly constructing the iron core; and in many other ways.

As a means of obtaining the required phase of the currents in both the circuits, the disposition of the two coils at right angles is the simplest, securing the most uniform action; but the phase may be obtained in many other ways, varying with the machine employed. Any of the dynamos

at present in use may be easily adapted for this purpose by making connections to proper points of the generating coils. In closed circuit armatures, such as used in the continuous-current systems, it is best to make four derivations from equi-distant points or bars of the commutator, and to connect the same to four insulated sliding rings on the shaft. In this case each of the motor circuits is connected to two diametrically opposite bars of the commutator. In such a disposition the motor may also be operated at half the potential, and on the three-wire plan, by connecting the motor circuits in the proper order to three of the contact rings.

In multipolar dynamo machines, such as use the converter systems, the phase is conveniently obtained by winding upon the armature two series of coils in such a manner that while the coils of one set or series are at their maximum production of current, the coils of the other will be at their neutral position, or nearly so, whereby both sets of coils may be subjected simultaneously or successively to the inducing action of the field-magnets.

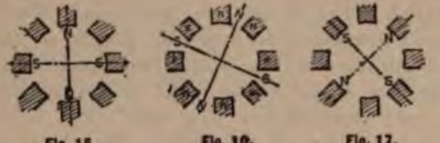


Fig. 15. Fig. 16. Fig. 17.

Generally, the circuits in the motor will be similarly disposed, and various arrangements may be made to fulfil the requirements; but the simplest and most practicable is to arrange primary circuits on stationary parts of the motor, thereby obviating, at least, in certain forms, the employment of sliding contacts. In such a case the magnet coils are connected alternately in both the circuits; that is, 1, 3, 5 in one, and 2, 4, 6 in the other, Fig. 15, and the coils of each set of series may be connected all in the same manner, or alternately in opposition, Fig. 16. In the latter case a motor, with half the number of poles, will result, and its action will be correspondingly modified, Fig. 17.

The employment of multipolar motors secures in this system an advantage much desired and unattainable in the continuous-current system, and that is, that a motor may be made to run exactly at a predetermined speed irrespective of imperfections in construction of the load, and, within certain limits, of electromotive force and current strength.

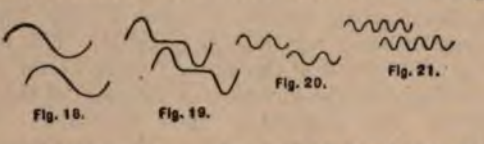


Fig. 18. Fig. 19. Fig. 20. Fig. 21.

In a general distribution system of this kind the following plan should be adopted. At the central station of supply, a generator should be provided having a considerable number of poles. The motors operated from this generator should be of the synchronous type, but possessing sufficient rotary effort to insure their starting. With the observance of proper rules of construction it may be admitted that the speed of each motor will be in some inverse proportion to its size, and the number of poles should be chosen accordingly. Still, exceptional demands may modify this rule. In view of this, it will be advantageous to provide each motor with a greater number of pole projections or coils, the number being preferably a multiple of two and three. By this means, by simply changing the connections of the coils, the motor may be adapted to any probable demands.

If the number of the poles in the motor is even, the action will be harmonious and the proper result will be obtained; if this is not the case the best plan to be followed is to make a motor with a double number of poles, and connect the same in the manner before indicated, so that half the number of poles result. Suppose, for instance, that the generator has twelve poles and it would be desired to obtain a speed equal to $\frac{12}{7}$ of the speed of the generator. This would require a motor with seven pole projections or magnets, and such a motor could not be properly connected in the circuits unless fourteen armature coils would be provided, which would necessitate the employment of sliding contacts. To avoid this, the motor should be provided with fourteen magnets and seven connected in each circuit, the magnets in each circuits alternating among themselves. The armature should have fourteen closed coils. The action of the motor will not be quite as perfect as in the case of an even number of poles, but the drawback will not be of a serious nature.

However, the disadvantages resulting from this unsymmetrical form will be reduced in the same proportion as the number of the poles is augmented.

If the generator has, say, n, and the motor n_1 poles, the speed of the motor will be equal to that of the generator multiplied by $\frac{n}{n_1}$.

The speed of the motor will generally be dependent on the number of the poles, but there may be exceptions to this rule. The speed may be modified by the phase of the currents in the circuits, or by the character of the current impulses or by intervals between each or between groups of impulses. Some of the possible cases are indicated in the diagrams, Figs. 18, 19, 20 and 21, which are self-explanatory. Fig. 18 represents the condition generally existing, and which secures the best result. In such a case, if the typical form of motor illustrated in Fig. 14 is employed, one complete wave in each circuit will produce one revolution of the motor. In Fig. 19 the same result will be effected by one wave in each circuit; in Fig. 20 by two, and in Fig. 21 by four waves.

By such means any desired speed may be attained; that is, at least within the limits of practical demands. This system possesses this advantage besides others, resulting from simplicity. At full loads, the motors show an efficiency fully equal to that of the continuous current motors. The transformers present an additional advantage in their capability of operating motors. They are capable of similar modifications in construction, and will facilitate the introduction of motors and their adaptation to practical demands. Their efficiency should be higher than that of the present transformers, and I base my assertion on the following:

In a transformer as constructed at present we produce the currents in the secondary circuit by varying the strength of the primary or exciting currents. If we admit proportionality with respect to the iron core, the inductive effect exerted upon the secondary coil will be proportional to the numerical sum of the variations in the strength of the exciting current per unit of time: whence it follows that for a given variation, any prolongation of the primary current will result in a proportional loss. In order to obtain rapid variations in the strength of the current, essential to efficient induction, a great number of undulations are required and employed. From this, various disadvantages result. These are increased cost and diminished efficiency of the generator, more waste of energy in heating the cores, and also diminished output of the transformer, since the core is not properly utilised, the reversals being too rapid. The inductive effect is also very small in certain phases, as will be apparent from a graphic representation, and there may be periods of inaction, if there are intervals between the succeeding current impulses or waves. In producing a shifting of the poles in the transformer, and thereby inducing currents, the induction is of the ideal character, being always maintained at its maximum action. It is also reasonable to assume that by a shifting of the poles less energy will be wasted than by reversals.

FACETIÆ.

SHE SAW THE GOLD.—"Mamma, I know it's true about the golden streets in heaven." "Why, how do you know that, darling?" "Because, when I was out with nurse last night, something made a great noise, and the sky split clear across; and then I saw the gold shining through."

A SNAKE STORY.—Swan's stand at the Inventions' Exhibition was one mass of incandescent lamps, and caused a great deal of curiosity to arise in the minds of country visitors. "Why, Maria," said one of two old dames after prying about inquisitively, "there's little snakes in them glass bottles." Fact!

PROTECTION OF THE HUMAN BODY FROM DANGEROUS CURRENTS.*

BY PATRICK B. DELANY.

Since the object of reading a paper before this Society should be the enlightenment of members on the subject under consideration by the presentation of facts developed by experimentation, or of theories supported by a reasonable amount of investigation, I must apologise for my delinquency in both respects, and trust to the kind indulgence of the Society in making a few suggestions, with a view of eliciting information and opinions from those whose experience and familiarity with the subject enables them to speak with authority.

I allude to what are considered dangerous currents and their effect on the human body. That there is danger in handling conductors conveying high tension currents must be generally admitted. The question, therefore, is, Can fatal results from such currents be wholly or partially averted? All will agree that, with proper care on the part of the companies, and intelligent co-operation on the part of employés, but little would be heard of the danger of electric currents. But companies are economical, and employés are careless. Familiarity with danger breeds contempt for it. This is exemplified almost daily in every department of industry. A new man in a powder mill will exercise the greatest care and observe all the rules of the establishment faithfully. In a few months the same man will smoke a pipe over an open powder keg.

Protection is necessary principally for those who through carelessness or ignorance fail to protect themselves. It has been claimed that there can be no such thing as an accident —that Nature has none, and that all so-called accidents are simply the results of miscalculation, bad judgment or carelessness. But it must be remembered that the vigilance of the most alert will sometimes relax, and this to them is the moment of danger.

Realising that something should be done to protect dynamo men and wire handlers from injury from powerful currents, I a few years since invented a device for shunting the vital parts of the body. Partly on account of a pressure of business in other branches of electricity, but principally owing to a hesitancy in bringing out a device about the efficacy of which there seemed to be some doubt, its introduction to scientific criticism was delayed until a few weeks ago. As the references made to the question in the electrical papers have failed to elicit an expression of opinion satisfactory to any degree, it has been deemed advisable to bring the subject before this meeting.

The question to be determined is, to what extent a wire of practically no resistance, extending from one wrist to the other, and bound around the wrists in numerous convolutions so as to make good, but not uncomfortable, contact, will protect the vital parts of the body from fatal injury when it is placed in the path of a dangerous current through contact at the hands. It is claimed by some that the current having once entered the muscles, veins and tissue at the hands, will not leave the arms at the wrists and follow the shorter path of the wire, but will confine its course to the arms and body alone. The other opinion is that the greater portion of the current received at the hands will leave the arms at the wrists and follow the wire. The problem seems a difficult one to solve. So much depends on the condition of the person at the time of receiving a shock, a large number of tests would be necessary to arrive at results which would afford a safe basis for calculation. A few years ago Dr. Stone, connected with one of the London hospitals, made a series of interesting experiments upon patients afflicted with various ailments, with a view of determining whether or not fluctuation in their physical condition affected the electrical conductivity or resistance of their bodies. The results proved, according to my recollection, that great changes took place in the electrical resistance of the patients experimented upon from day to day, and that there was a direct influence manifested by the rise and fall of different diseases upon the electrical conductivity of the body as a whole or in part. An account of Dr. Stone's experiments was published in *Nature* at the time. But while the experiments are most valuable for the purpose for which they were intended, they throw but little light on the subject of dangerous currents and protection from fatal injury.

Last September there was published in the *Electrical Review* of London a paper on "Shocks from Alternating Currents," by Mr. G. L. Addenbrooke, who for some time previous had charge of the Grosvenor Gallery installation, where a primary current of 2,500 volts was constantly employed. While no one had ever come in contact with both mains at once, the writer stated that even if such an accident had happened he was "by no means prepared to assert that the result would undoubtedly be fatal." "Indeed," says he, "I rather incline to the opinion that if the subject of the shock were healthy, and the circumstances under which he received it were favourable, the chances are he would survive."

I cannot make out what Mr. Addenbrooke means by receiving 2,500 volts under favourable circumstances. It seems to me, if they are received at all, the circumstance could not be other than unfavourable. Mr. Addenbrooke himself received a severe shock, and as he speaks from experience I quote his account of how it affected him: "The primary effect of the passage of the current through the body, is of course, to contract the muscles. The amount and persistance of this contraction depend on the quantity of the current flowing, or, as it is usually designated, the *intensity* of the shock, and varies from a simple twitching of the limbs to complete and intense contraction or rigour of apparently every muscle in the body. In this latter case the current completely supersedes the action of the mind over everything capable of contraction or movement. Consciousness, however, is apparently rarely, if ever, lost, though the subject may be entirely unable to make any motion, cry out, or do anything to help himself. If aid is not near, such a state may be maintained for some time. On release from such a position by extraneous or natural causes, the subject is usually dazed, but if at all unconscious, soon recovers completely and experiences no further functional disturbance than the debility and nervousness naturally following such a severe strain on the system." While admitting that fatal shocks are possible, this gentleman gives it as his opinion that "if the shock is not sufficient to cause instantaneous collapse, apparently the body can bear the strain of the continued passage of the current for some time," and that death is caused by paralysis of the involuntary muscles controlling the heart and lungs, and that the preliminary stages of total collapse are analagous to what occurs when drowning." Referring to the local action of the current on the body where it enters and leaves, this writer also says: "If the contact is good, that is, if it consists of a good area, say of over a couple of square inches of a fairly moist skin pressed with moderate firmness against a metallic body or other good conductor, no visible injury may resnlt. For instance, a man will often get burnt about the hands, but his feet, by which the current leaves, will be unaffected, or only slightly reddened or inflamed. Burning of the hands or other parts of the body will occur when there is imperfect contact of the body with the conductor, coming in contact with a bad or semi-conductor such as a dirty or carbonised surface. The burning is caused by the absolute setting up of an arc."

It seems to me this gentleman's views, based, as we are led to believe, on actual experience, are somewhat paradoxical. And surely numerous cases of deaths from currents recently disprove many of Mr. Addenbrooke's deductions. True, nothing short of death is made public, so that there is but little information to go upon relating to the instances which must be of frequent occurrence where men are *almost* killed by electric shocks. In all cases that have come to light, whether simply injurious or cases of death, the parts of the body coming in contact with the current have been badly burned. The unfortunate "Trouble Hunter," who lost his life a few days since, was not only burned at the hands but at the knees. In cases where the shock is not instantly fatal, may it not be that the burning of the flesh at the points of contact is so great as to destroy to a considerable extent the conduct-

* Read before the American Institute of Electrical Engineers, May 16, 1888.

ing substance in contact with the wire, and thereby cause a fall in the current passing through the body? It is certainly owing to the fact of the body being a very poor conductor that harm is done. If it offered no resistance, there would be no realisation that a current was passing through it. An arc would be created at the point of contact, provided the contact was *imperfect*, but the body itself would be uninjured. It seems to me that the human body must be view as any other semi-conductor, with the exception, perhaps, of susceptibility to greater change under the continued action of a current, owing to the fluids which it contains. It is owing to its resistance that a carbon filament becomes incandescent. The carbon rod of an electric lamp is not consumed except at the point where the arc is formed by the resistance of attenuated particles under combustion. Any conducting substance placed in the path of more current than it is capable of conveying must be heated, consumed, or decomposed, according to its nature and in proportion to the discrepancy between the conducting capacity of the conductor and the sum of the current.

Now, if we liken the human body from hand to hand to a canvas hose or tube filled with water, and which allows a certain quantity of moisture to ooze through the surface, corresponding to the moisture of the skin, and if this be inserted in a circuit, connection being made at the extreme ends, corresponding to the hands, and a shunt wire of minimum resistance be wound around the tube two or three inches from the ends, corresponding, say, to the wrists, we can, perhaps, more understandingly speculate on the action of a dangerous current on the human body, contact being made at the hands and the shunt wire encircling the wrists. It should be borne in mind that the contact between the shunt wire and wrists is much better than the contact at the hands, since the wrists are more tender than the hands. Now, referring to the tube and assuming that the contacts at the ends have improved by reason of the currents eating its way into the water, does it not follow that the current, instead of following the entire length of the tube of water, offering, say, thirty times the resistance of the two or three inches of water from the end of the tube to the shunt wire, and several thousand times the resistance of the shunt wire itself, will, to a great extent, pass from the tube to the shunt wire, and in its passage *improve* the contact at that point as it did at the ends in entering the tube? I have often noticed that upon receiving a shock of 150 to 250 volts profuse perspiration instantly followed. This would greatly improve the contact at the wrists above the normal, so that it would seem impossible that the current should confine itself to the fluids and muscles of the body in preference to the wire when separated from the wire only by a thin tender skin filled with moisture.

In considering the danger point of currents it seems reasonable to recognise the same law, or rather recognise the absence of any law, governing other destructive agencies. Let it be concussion, strain, asphyxia, poison, or other enemy of endurance, there are hardly two cases alike. One man may emerge with but slight injury from a cause which to another man would be death. Why should it not be so in the matter of electric shock? Death, of course, must be the consequence of a certain degree of cause. If 2,000 volts are necessary to kill in any instance, one volt less would avert death, while shunting 100 or 500 volts would leave a proportionate margin of safety. Fatal results through the medium of electricity do not come by jumps any more than by any other force or element of destruction. There is in this subtle agency, as in all others, a last straw which breaks the camel's back—a last volt which does the final harm. Hence the importance of protecting, as far as possible, those exposed to this danger.

Regarding the immediate cause of death or the effect of currents on the substances of the body, we must look to the medical men for light. Probably all subjected to shock might not be similarly affected. In one case it might be the heart, in another the brain, and in others the lungs that might be injured. Why not have a thorough investigation of this subject, and then, perhaps, wire handlers may be subjected to an examination before they are allowed to engage in such work, just as men are examined for various other duties.

There seems to be so little known about these matters, I shall feel gratified if this paper serves as even a feeble incitement to discussion and investigation, as I can conceive of no subject offering a more humane incentive.

THE S.S. "INANDA."

The steamship "Inanda," by Messrs. Hall, Russell and Co., Aberdeen, belonging to Messrs. John T. Rennie and Sons, 6, East India-avenue, just built for trading to Natal, South Africa, has been fitted with electric light by Messrs. J. H. Holmes and Co., Newcastle-on-Tyne. The installation is a small one, but is very neatly and carefully fitted throughout. The engine, 6 h.p. nominal, is one of the "Archer" type, by Tangye Bros., Birmingham, direct driving at 280 revolutions with 80lb. pressure. The dynamo is Messrs. Holmes' "Castle" type; a larger size is used with this slow speed, and gives 65 amperes at 55 volts. Edison-Swan 50-volt incandescent lamps are used, and the wiring throughout is on the single-wire or earth-return system. One of the main cables is cut off, and a bare loop is made, which is bolted securely to the framework of the ship. Only one wire is therefore used for wiring throughout, the return being to the framework of the metal fittings of the lamp. Drake and Gorham holders, with porcelain bases, are used, and short brackets for the cabins, wich obscured globes, are fitted with push switches in the bases of each bracket, designed by the same firm. The switch board is arranged with Holmes' instantaneous-break main switches near the dynamo and engine, which are installed in a small compartment the height of a man, up a few stairs in the main engine-room, and the running is extremely smooth and silent. There are sixty-four 16 c.p. lamps in all, and the hatches are fitted with three large "Sunbeam" lamps of 200 c.p., with reflectors, hung with running gear to a spar above. The engine-room is fitted with portable hand-lamps, with 30ft. of flexible, and the side lights, red and green, have each a sliding fitting with two incandescent lamps each, which can be replaced with the usual oil-lamps if necessary.

PHYSICAL SOCIETY—June 9.

Prof. REINOLD (President) in the chair.

Mr. J. L. Howard, D.Sc., was elected a member of the Society.

The following papers were read:—

"On the Analogy between Dilute Solutions and Gases as regards Gay-Lussac's and Boyle's and Avogadro's Law," by Prof. Van't Hoff, presented by Prof. Ramsay, F.R.S.

"On a Method of Comparing very Unequal Capacities," by Mr. A. H. Fison, D.Sc. One coating of each condenser is joined to earth and to one end, A, of a high resistance (20,000 or 30,000 ohms), through which a current is flowing. The small condenser is charged to the P D existing between the ends, A B, of the resistance, and discharged into the large one. This is repeated a great number of times. If C be a point between A and B, the resistance between A and C may be varied until the P D between them is equal to that between the coatings of the condensers after n operations. If the insulated coatings be now joined to C through a galvanometer, no deflection will result. The relation between the capacities C_1 and C_2 of the large and small condensers is given by $\left(1+\frac{C_2}{C_1}\right)^n = \frac{R_{AB}}{R_{BC}}$, where R_{AB}, R_{BC}, are the resistances between A B and B C respectively.

Since time is required to perform the operations, the instantaneous capacities cannot be compared, and accordingly the measurements are taken after a definite time of electrification. A special rotating key was shown for performing ten operations per revolution, in which a trigger arrangement was provided for stopping the rotation after a predetermined integral number of revolutions. The method has been used for comparing a small air-condenser with a microfarad. The capacity of the former was also calculated electrostatically (correction being made for the edges), and that of the latter measured electro-magnetically by a ballistic galvanometer. The results give a value for v equal to $2{\cdot}965 \times 10^{10}$. In these experiments the capacity of the rotating key was allowed for. Under favourable conditions, capacities in the ratio of 1 to 1,000 or 1 to 10,000 can be compared with an accuracy of ½ per cent.

Prof. Ayrton thought the novelty of the arrangement was in the rotating key, as the method of comparing unequal capacities by charging the smaller and discharging it into the larger a considerable number of times had been described and used by himself and Prof. Perry in their experiments on the specific inductive capacity of gases.

Mr. W. Lant-Carpenter exhibited a new form of lantern, recently constructed by Mr. Hughes, of Dalston. The mahogany body is

hexagonal, and each of the three front sides is provided with condensers and projecting arrangements. The back part opens to give access to the radiant, which in this case is a Brockie-Pell arc lamp, but, if necessary, a lime light can be readily substituted. The lamp is fixed to the base-board, and the body can be rotated through 60deg. on either side of the central position, thus allowing any of the three nozzles to be directed towards the screen. The three sets of condensers are placed so that their axes intersect at a point about which the radiant is placed. The centre nozzle is fitted as a lantern microscope, with alum cell, and various sets of condensing lens and objectives, and a space in front of the main condensers is provided for polarising apparatus. The focussing arrangement consists of a skew rack and pinion and a fine screw adjustment, and the whole microscope can be easily removed and a table polariscope substituted. The right-hand nozzle is arranged for the projection of ordinary lantern slides, and the left-hand one is provided with an adjustable slit for spectrum work. A small table, sliding on rails, serves to carry the prisms, and the same rails support projecting lenses.

Prof. S. P. Thompson congratulated Mr. Lant-Carpenter on his selection of the Brockie-Pell lamp as the radiant, for in addition to its being a focussing lamp, it was unique, in the fact that it works satisfactorily on either constant current or constant potential circuit.

"Note on Some Additions to the Kew Magnetometer," by Prof. H. Thorpe, F.R.S., and Prof. Rucker, F.R.S. In their magnet survey of Great Britain and Ireland the authors have experienced considerable difficulty in making the necessary adjustments of the small transit mirror used for determining the geographical N point from observations on the sun. To make the required adjustments, it is necessary to obtain an image of the cross wires reflected from the mirror, and, owing to the large amount of extraneous light and the insufficient illuminator of the cross wire, the image is difficult to see. To exclude extraneous light, a tube is placed between the transit mirror and the telescope, and a small screen placed behind the mirror. The cross wires are illuminated by light reflected from a small platinum mirror introduced between the eye piece and the cross wires, which are viewed through a hole in its centre. The mirror is placed at 45degs. to the axis, and reflects a considerable quantity of light on the cross wires when directed towards a bright part of the sky. In some cases it is advisable to take observations of the sun without first adjusting the transit mirror, and afterwards correct the error introduced thereby. To do this, a finely-divided scale is placed in the plane of the cross wires, and from the position of the image, as indicated on the scale, the correction can be made. Observations taken with the mirror in adjustment, and others taken when out of adjustment and subsequently corrected, give very concordant results.

The **Rev. Father Perry** said the improvements described were of great importance, for difficulties similar to those experienced by the authors had caused him to abandon the Kew magnetometer for field work, and to use a theodolite instead.

COMPANIES' MEETINGS.

THE INSTITUTE OF MEDICAL ELECTRICITY, LIMITED.

The first ordinary general meeting was held at Essex Hall, Essex-street, W.C., on the 7th inst. Mr. W. Lant-Carpenter was voted to the chair. He explained that though the meeting was called in accordance with the requirements of the statute, the Directors had but little to report, since they had been unexpectedly obliged to delay the opening of an establishment in London. This was mainly owing to certain negotiations with the Royal College of Physicians, which, he hoped, however, would soon be satisfactorily completed, and they had reference to the appointment of medical officers to the institute. The Directors had given considerable attention to the welfare of the institute, having held sixteen Board meetings since the Company was registered. Mr. F. L. Rawson, M.S.T.E. and E., had joined the Board, and it had been unanimously decided that no Directors' fees would be accepted till a dividend of 6 per cent. per annum should have been declared.

The meeting cordially approved the action of the Directors with reference to the Royal College of Physicians, and a resolution was passed confirming an agreement provisionally entered into by the board, by which the institute acquires the business of the Electrified Rooms Company, Limited, of London. This has been carried on for over twelve months with the warm approval and support of over forty local medical men, upon a similar principle to that adopted by this institute, viz., that no electrical treatment is administered to any patient without the concurrence and upon the prescription either of his own medical man or of the medical officer of the institute.

PROVISIONAL PATENTS, 1888.

JUNE 1.

8039. **Improvements in or relating to the transformation or conversion of electric currents.** Alfred Le Clercq and Achille Vansteenkiste, 6, Lord-street, Liverpool.

8062. **A combined electrical time switch and electrometer.** Ferdinand Kleiner, 18, Buckingham-street, Strand, London.

JUNE 4.

8161. **Bleaching paper pulp by electricity.** Charles Cecil Nichols, of the firm of C. A. and H. Nichols, 21, Mincing-lane, London, E.C., on behalf of the London Electric Bleaching Company. (Complete specification).

8081. **Improvements in and relating to electrical bells, indicators, and such like.** Walter Rowbotham and William Fox, 39, Lever-street, Manchester, Lancashire.

8099 **Improvements connected with electrical hoists or cranes.** Rookes Evelyn Bell Crompton, John Francis Albright, and Jorgen H. Ferdinand Soll, Arc Works, Chelmsford.

8160. **Production by electricity of chlorine and its oxygenated compounds, and their utilization thereof.** Emily Marie Hippolyte Andreoli, 62, Loughborough-park, Brixton, S.W.

JUNE 5.

8170. **Improvements in governing devices for electric motors and circuits.** Herbert John Allison, 52, Chancery-lane, London. (The Baxter Electric Manufacturing and Motor Company (Incorporated), United States.) (Complete specification.)

8171. **Improvements in magneto-electric liquid level indicators.** John Joseph Ghegan, 52, Chancery-lane, London. (Complete specification).

8200. **Improvements in electrical transformers.** Walter Thomas Goolden and Henry Willock Ravenshaw, 23, Andulus-road, Clapham, S.W.

JUNE 7.

8354. **Improvements in the manufacture of depolarizers for primary or secondary electric batteries.** Maurice Leclanché, 169, Fleet-street, London.

COMPLETE SPECIFICATIONS ACCEPTED.

JUNE 8, 1887.

8240. **Improvements in galvanic batteries.** John Randolph Hard and Thomas Wilson, 191, Fleet-street, London, E.C.

JUNE 13, 1887.

8500. **Improvements in conduits for electric wires or cables.** Richard Solomon Waring, 24, Southampton-buildings, London.

JUNE 16, 1887.

8701. **Improvements in and relating to the production and application of electric energy for lighting or other purposes.** John Ross, 96, Buchanan-street, Glasgow.

JULY 19, 1887.

10,071. **Improved fittings for electric incandescence lamps.** Wm. Brooks Sayers, 231, Monument-road, and Wilson Henry Sturge, 17, Frederick-road, both in Birmingham.

AUGUST 4, 1887.

10,740. **Improvements in regulators for electric lamps.** Sylvain Mathis, 45, Southampton-buildings, London.

OCTOBER 7, 1887.

13,601. **Improvements in "automatic" coin-freed electrical machines, and in the method of displaying advertisements therein.** John Hubert Davies and Alfred Thompson, 45, Southampton-buildings, London W.C.

OCTOBER 21, 1887.

14,346. **An improved bell-pull electric-light switch.** Andreas Peter Lundberg, 18, Regina-road, Tollington Park, London, N.

NOVEMBER 16, 1887.

15,703. **A galvanic battery for medical purposes.** John Court, 136, Brompton-road, London, S.W.

FEBRUARY 23, 1888.

2703. **Improved means or apparatus for sounding at sea and elsewhere by electricity.** Frederick Hargrave, 38, Chancery-lane, W.C.

MARCH 10, 1888.

3752. **Manufacture of composition for the construction of roadways, pavements, building blocks, telegraph poles, railway sleepers, and similar articles, and for the manufacture of fire-proof and preservative paint.** Oliver Imray, 28, Southampton-buildings, London, W.C. (George Seth Lee, United States.)

APRIL 24, 1888.

6076. **Electrical appliances for a mariner's compass to give alarm upon deviation from the ship's course.** Augustus Gross, 45, Southampton-buildings, London, W.C.

SPECIFICATIONS PUBLISHED.

1887.

7189. **Secondary batteries.** W. H. Akester. 8d.

8206. **Producing electric light by insertion of coin.** D. H. Davies and J. M. Tourtel. 8d.

8495. **Electric lamps.** A. M. Clark (Bertou.) 1s. 1d.

9598. **Electrical apparatus for working railway signals.** I. A. Timmis. 8d.

1888.

3246. **Electrical lamp and projector, &c.** F. Walker. 8d.

3303. **Registering the consumption of electric energy.** H. H. Leigh. (Clerc.) 8d.

5203. **Transmitting sounds.** L. J. LePontois. 8d.

1882.

4362. **Distributing electricity.** L. Gaulard and J. D. Gibbs. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	3¾
26 April	1%	Anglo-American	100	36½
26 April	2%	— Pref.	100	62
12 Feb., 85...	5/0	— Def.	100	12¼
28 Mar.	3/0	Brazilian Submarine.........	10	12½
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	9
28 Mar.	2/0	Direct United States	20	8½
12 April	2/6	Eastern	10	11¾
12 April	3/0	— 6% Pref.	10	15
1 Feb. ...	5%	— 5%, 1899	100	111
26 April	4%	— 4% Deb. Stock	100	108
26 April	3/6	Eastern Extension, Australasia & China............	10	13
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	103½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5¾
12 April	3/0	— 6% Pref.	10	13
30 April	5/0	Great Northern	10	13⅞
1 Mar.	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17½
11 May	37/6	Indo-European	25	40
16 Nov.	2/6	London Platino-Brazilian...	10	6x
16 Mar.	5%	Maxim Weston	1	⅛
26 April	2½	Oriental Telephone	11	⅜
26 April	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2⅜
15 Feb.	15½%	Submarine	100	150
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	14½
......	...	West African	10	5
1 Mar.	5%	— 5% Debs.	100	92¼
29 Dec.........	6/0	West Coast of America ...	10	6⅛
31 Dec.	8%	— 8% Debs.	100	117
11 May	9/	Western and Brazilian......	15	10⅛
11 May	6/10½	— Preferred	7½	6⅝
11 May	2/1½	— Deferred..................	7½	4
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	108
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	11¼
13 May, '80...	...	— 6% 2nd Pref.	10	7½
2 May	7%	West Union of U.S.	$1,000	123
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. June 8 ...	£4,311	...
Cuba Submarine	M. of May ...	4,437	+ £736
Direct Spanish......................	M. of May ...	1,800	+ 119
— United States	None	Published.	...
Eastern..............................	M. of May ...	49,003	+ 8,446
Eastern Extension	M. of May ...	£40,586	+ £1,376
Great Northern	M. of Apl. ...	21,400	...
Submarine	None	Published.	
West Coast of America	M. of Apl. ...	4,405	...
Western and Brazilian	W. June 8 ...	3,606	...
West India and Panama	F. April 30 ...	3,268	+ 231

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended June 8 amounted to £4,311.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company for the week ended June 8, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, amounted to £3,606.

The "Electrician" Printing and Publishing Company, Limited. Registered by Bircham and Co., 50, Old Broad-street, E.C., with a capital of £10,000 in £10 shares. Object, to acquire the business of the proprietors, printers, and publishers of the *Electrician* newspaper. The first subscribers are:—

	Shares.
Sir J. Anderson, 62, Queen's-gate	1
J. D. Pender, 51, Hans-place, S.W.	1
L. Schott, 4, Bank-buildings, E.C.	1
L. Floersheim, 4, Bank-buildings, E.C, ...	1
K. L. M. Anderson, 10, Throgmorton-avenue, E.C.	1
J. Pender, K.C.M.G., 18, Arlington-street, S.W.	1
J. Pender, Thornly Hall, Northampton.........................	1

The first directors shall be nominated in writing by the subscribers to the memorandum of association, and their remuneration shall be determined in general meeting.

The De Humy Cabinet Battery Syndicate, Limited.—Registered by Haskes and Crawford, 65, Lincoln's-inn-fields, London, W.C. Capital, £15,000, divided into 60 shares of £250 each. Object, to acquire by purchase, or otherwise, work and carry out the valuable invention patented by P. R. de F. de Humy, for domestic electric lighting, called the De Humy Cabinet Battery; to take out patents for the colonies and other countries, and sell or work the same; to carry on the business of manufacturers and dealers in all sorts of machines, chemicals, carbon and appliances for the production, transmission, and storage for electricity, and for its application and use for the storage of electricity, and for its application and use for the purposes of lighting, or of motive power, and generally the business of electrical engineers in all its branches. The first subscribers are:—

	Shares.
J. Davison, 8, The Avenue, Upper Norwood...............................	1
W. W. Prole, Croydc, Devon	1
J. Johnstone, 14, Manor-place, Paddington-green	1
F. de Humy, C.E., 2, Carlton-mansions, Clapham-rise	
J. T. Browne, C.E., 32, Rue Baudin, Paris	1
B. H. Hertslet, Belle Vue House, Richmond	1
F. B. Lidstone, land agent, 58, Warwick-road, S.W.	1

Registered without articles of association, and therefore the clauses of the first schedule of the Companies Act, 1862, will apply.

NOTES.

House of Commons.—The Electric Lighting Amendment Act was read a third time on Friday evening, June 15.

Telephoning to Lighthouses. — It is proposed shortly to connect the Eddystone Lighthouse with Plymouth by telephone.

Vienna.—The Austrian Government has granted the Anglo-American Brush Corporation a concession for public lighting in Vienna.

India.—Owing to the fall in exchange, the rates for foreign telegrams to Europe will be increased by 3 annas a word on the 1st of July.

Conversazione.—Invitations have been issued by the President of the Society of Telegraph-Engineers for a conversazione on the 10th July.

Crossley Bros.—Messrs. Crossley Bros., Limited, will open a warehouse and show-room for Otto gas engines in St. Bride-street, Ludgate-hill, next week.

Galvani Centenary.—An interesting ceremony, the celebration of the centenary of Galvani's discoveries in electricity, was celebrated at Bologna on the 14th inst.

Book Received.—"Short Lectures to Electrical Artisans," by Dr. J. A. Fleming (Spon, 1888). A second edition of this clear and interesting set of lectures has just been published.

Telephone Union.—The United Telephone Company have tried to rush a Bill through the House of Commons, but the Metropolitan members have unanimously agreed not to support the Bill.

Disabled by Lightning.—At Elizabeth, New Jersey, the arc lighting system was temporarily disabled by a lightning stroke during the storm of May 28, and every lamp was extinguished.

Perpignan.—The town of Perpignan is to be lighted by electricity from a central station, to be installed by M. Lamy, who has already established several other central stations in French country towns.

Ignifuge.—A new paint called "Ignifuge Martin" is being introduced for prevention of fire risks. It may be used for painting wood casing for the electric light wires. The London agent is Mr. Walter Gilbert, 6, Dowgate-hill, E.C.

Accumulators in America.—The use of accumulators for public lighting is greatly extending in America. Kansas City is to have a plant of 10,000 lights, at which the accumulator system is to be used. Several other towns in Kansas are following suit.

Value of the Ohm.—M. Wuitteumier has arrived at a fresh determination of the value of the ohm, by the method proposed by Lippmann. He gives it as the resistance of a column of mercury having a section of 1 millimetre square and a length of 106·27 centimetres.

Mordey's Alternator.—In our notice of this machine it should have been stated that the alternators to be erected in Oxford-street are at Mr. Pritchett's lighting station. For the illustrations used in our article, so far as regards Figs. 1, 2, and 3, we are indebted to the courtesy of our contemporary *Industries*.

Short System in Ohio.—The Short series system of electric trams is being introduced at Columbus, Ohio, where a plant of 250 h.p. is being erected, to operate 50 street cars on 10 miles of double track. Mr. Charles F. Brush, of Cleveland, is said to be interested in the enterprise, and Brush motors are to be used.

Cheap Aluminium.—The Hon. F. J. Kingsbury and the son of Mr. Waterbury, Conn., are associated with some New York capitalists in a company for the manufacture of the alloys of aluminium and silicon produced by the furnaces of the Cowles Electric Smelting and Aluminium Company at Lockport, N.Y., on a large scale for the market.

Hot-Air Engine.—M. Benier has invented an improved hot-air engine, with which some importants results have been achieved, according to *Dingler's Polytechnische Zeitung*. The working temperature is 200deg to 240deg. centigrade, and the consumption of coke in a 6-h.p. engine was 3·3lb. per h.p. on light loads, and 2·4lb. on heavy loads.

Richmond Union Tramway.—This electric tramway, which we described last week, is one of the most extensive at present in use. Forty cars are now running from one station, and the cost, including depreciation and everything except executive expenses, proves to be only 4·32 cents (2·16d.) per car mile. The cars are crowded, and success seems guaranteed.

"Waring" Cables.—In response to enquiries respecting the high tension underground cables in Philadelphia, mentioned in our issue of 8th inst., the cables there referred to as working satisfactorily with a high-tension current, are the "Waring" cables, eulogised by Mr. Preece in his paper on fire risks. We believe these cables will shortly be introduced to the English market.

New Filament.—We hear that Messrs. Woodhouse and Rawson are introducing a new method of producing filaments for electric lamps, of carbons of such hardness, fineness, and elasticity, that considerable power may be exerted in bending the filaments without breaking. Buttons made of the new carbon shine like jet, and will bend perceptibly under pressure with the fingers.

Women Glass-Blowers.—The new Sawyer-Man factory in New York is an immense and well-furnished establishment. The mercury pump-room will have 240 pumps when complete. Where men glass-blowers were formerly employed, the superintendent has introduced women, who are, he says, more expert than the men, and are able to turn out several times more lamps at less expense.

Electric Damper.—The Curtis damper regulator is finding much favour in the States. In this device, regulation by electricity has been applied to the movement of a damper in the flue of a steam-boiler, so as to obtain a marvellous uniformity of boiler pressure, many of the regulators closing and opening the damper with a variation of boiler pressure inside of one pound, and maintaining the pressure with very slight variations.

The Earth's Magnetism in "Tempering."—A Philadelphia tool manufacturer instructs his workmen to hold large steel tools in a north and south line while they are being tempered. He says that many years ago he noticed that such tools would often fly apart when being tempered if held "east and west," and that the liability to such accidents was greatly lessened, if not entirely obviated, if the tool was held "north and south."

New Telegraphic Code.—"The K. K. Complete Code" is the title of a new telegraphic code by W. J

Sutherland, published in London by Messrs. Eyre and Spottiswoode, and in New York by Messrs. E. and J. B. Young and Co. The system on which this code has been compiled is said to be a great improvement on all its predecessors, and will be found most useful to people having a large amount of telegraphing to do.

Milan.—The Societa Generale di Elettricita of Milan announce an increase of 147 incandescent and 64 arc lamps. This company had installed over 11,000 incandescent lamps, and 210 arc lamps. A profit of 132,342f. is shown to the end of 1887, and a dividend of 10f. per share of 250f. has been declared. The dividend for the previous years had been of 4f. and of 7f. respectively, and the present year shows a continued increase of success.

Admiralty.—In the presence of officers from the Admiralty, trials of the torpedo and electrical fittings of the undermentioned vessels will be made in accordance with the following programme :—"Belleisle," search light and torpedo fittings, June 22. With the search light only :—"Thames," June 22; "Spider," 25; "Sandfly," 25; "Racoon," 26; "Undaunted," 29; and "Serpent," July 2 Internal lighting:—"Thames," June 23; "Racoon," 27; and "Serpent," July 3.

The Radio-Micrometer.—The radio-micrometer, invented by Mr. C. Vernon Boys, F.R.S., consists of a small thermo-electric element, formed of a bar of antimony and bismuth, of small sectional area, the ends being formed by a loop of copper wire, suspended by a torsion fibre in a strong magnetic field. It is possible to observe by its means a difference of temperature of one ten-millionth of a degree centigrade, or, more graphically stated, will indicate the heat from a single candle at a distance of one mile.

Distribution of Power.—The distribution of steam by pipes to various factories is a recognised business in New York. Mr. Albert Gray, who has a large connection in this way, has established a similar distribution of power by means of electricity, and has a plant with a capacity of 450 h.p. at work on the water-side, of which he is supplying 280 h.p. to 80 customers for use with motors. He is erecting a further plant capable of distributing 1,500 h.p., as the demand is increasing far beyond his present capacity.

Electromotive Force of Lightning.—Prof. Weber has been making some experiments with lightning with two insulated conductors, connected to 400 collecting points, on the summit of the Riesengebirge. The current, measured with a galvanometer, varied generally between 0·07 to 2·5 micro-amperes. The E.M.F. was judged by the length of spark, and varied from 3,000 to 10,000 volts. On quiet nights no sparks occurred. The potential rose during disturbances to 11,000 to 20,000 volts, with a current of 4 to 8 micro-amperes.

Motors in Berlin.—Several central stations are at work in Berlin, and these are now beginning to appreciate the advantage of being able to supply power for small motors during the daytime. The price varies according to circumstances. The average prices for the supply of 3,000 hours a year is as under: for motors of

1.	2.	3.	5.	8 and	12 h.p.
0·38.	0·72.	1·05.	1·70.	2·64 and	3·98 marks per hour.

The use of these motors—especially those of smaller size—is very rapidly increasing.

Personal.—Mr. J. R. Williamson, A.M.I.C.E., who has up till now been manager of the Manchester Edison Electric Light Company, and under whose auspices the company has attained its present position, has been elected by a special motion of the directors to a position on the Board, and on taking his seat was unanimously elected managing director. We congratulate Mr. Williamson upon the esteem in which he is held, and trust the progress made in Manchester and district by this company will be increased under his more active guidance.

Catalogue Received.—We are in receipt of a catalogue of electrical fittings, very fully and neatly got up, from the General Electric Apparatus Company (Binswanger and Company), 5, Great St. Thomas Apostle, E.C., containing descriptions and illustrations of all electrical necessities that they can supply—from electric bells to steam engines, primary batteries and electric jewellery to dynamos and accumulators. Several specialities are included, and a general view of the present state of electric industries can be obtained in this agency catalogue.

Langham Hotel.—The whole of the cables and wires, as well as the switches and electroliers, &c., for this large installation were specially made for this installation, and the whole of the work has been completed in four months, and considering the thorough character of the work, it may be said to be one of the quickest installations recorded in the electrical world. The work was carried out under the direction of Mr. J. Elwin Coles, the manager, and Mr. J. G. S. Cunnington, the electrical engineer of Messrs. B. Verity and Sons, of King-street, Covent Garden, not Messrs. Verity Bros., as stated in our last issue.

Bogey.—We once heard a parson give as the reason why he did not take his text so that he could sermonise upon familiar topics, that if he did so, some specialist of the congregation would surely take him to task for not better understanding Nature's connection with science. He admitted he knew nothing of scientific progress or scientific views, and we suppose the same applies in the case of the "British Association of Medical Electricians," so far as the selection of president is concerned, for we have yet to learn that Mr. C. B. Harness, who has been elected to this position, is an electrician, medical or otherwise.

Folkestone.—The Folkestone Corporation at the last meeting discussed the report of the Electric Lighting Committee upon the subject of lighting the Lees by electricity, and as to entering into a contract with Messrs. Laing, Wharton, and Down, or any other firm for that purpose. Mr. Logan moved the adoption of the report, which was seconded by Mr. Payer. Mr. Thompson moved as an amendment that the report be referred back to the committee, with a view to modify their scheme. This was seconded, but on being put was lost—4 voting for it, and 8 against it—and the original motion was carried by 7 votes to 5.

Bath.—A private meeting of the principal citizens of Bath (who are also the largest comsumers of gas in the city) was held at the Grand Pump Room Hotel on the 15th inst., when it was decided to take at once the necessary steps for the formation of a local company for supplying Bath with the electric light for private and public use. It was decided to send in a tender to the Corporation for the lighting by arc lamps of a central area, at a price that would pay 5 per cent. upon the capital employed. Mr. Massingham, who was present, promised to find £5,000 of the capital required, and also to assist the company in others ways.

More Copper.—M. Dupont, director of the Museum of Natural History at Brussels, has found evidences of large deposits of copper on the Congo on the Zassair River; so that we need not be dependent on present supplies. The Copper Syndicate, however, will be no more before this comes into the market. A very important discovery of copper is also reported to have been made near Frankford, Tasmania. It is stated that one lode, 14ft. in width, has been struck, and that there are indications of numerous other lodes. Assays have been made both on the spot and in South Australia, and give favourable results as to copper and a fair percentage of gold and silver.

Mr. J. Willing, the Inventor.—A paragraph is going the round of the daily press, in which it is given to appear that Mr. J. Willing, jun., has patented a contrivance which enables that to be done which could not have been otherwise have been done—namely, to use the electric light on an omnibus or tramcar. We have heard of Willing, the advertiser; but Willing—or Snilling, or Billing—the "inventor"—never. According to these wise paragraphers, nobody has ever been able to light a car by electricity till now. We might tell them that any schoolboy could do it, if allowed the use of the necessary "storage-boxes" mentioned, by the joint action of the omnibus directors and the Electrical Power Storage Company.

New Method of Reading Reflecting Instruments.—*Science* gives the following abstract of a paper by M. F. Drouin in the *Lumière Electrique*:—"The usual mirror is replaced by a thin disc of glass. The scale being behind the instrument, the observer in front sees the scale directly through the glass, while he sees reflected from the front surface of the glass the image of an object, such as a black line on a white background, placed in front of the instrument, and to one side. When the glass disc is deflected through an angle, a, the virtual image of the mark is displaced through a distance, d. tan. $2a$ (d = distance from glass to scale). The method can be used in a well-lighted room, and does away with lamps and shades."

Society of Arts Conversazione.—The annual conversazione of the Society of Arts was held on Wednesday at the South Kensington Museum, and was largely attended. Among the guests received by Sir Douglas Galton and the members of the Council were several Indians, whose picturesque dresses add so much to the effect of these gatherings. The building was brilliantly lit up throughout, and the exhibits were seen at their best. The picture galleries were less crowded than other parts of the building, so that those guests who sought the comparative retirement of the galleries had ample time and opportunity to admire the Raphael cartoons, the Sheepshank's collection, and the new pictures which have been added to the museum from time to time.

Conscious through it all.—Superintendent Jeffries, of Lawrence (Kansas) Electric Light Company, relates his experience with a high-tension shock. When adjusting the brushes the other night, his body accidentally came in contact with the brushes, and the city circuit used his body as a conductor, and for about twenty seconds gave him such a shaking he doesn't care to have repeated. The blood was forced through the ends of his fingers, and the palms of his hands were burned. He remained conscious through it all, but was unable to move or regain his power of speech for several minutes after his release. It might be interesting to inquire how long will a Yankee prisoner be conscious after his power of speech and movement are gone wheit executed under the new law.

Air Cushion.—Now that motors are being introduced for all manner of purposes, that of raising lifts will not be forgotten. We notice a trial has just been made with an air cushion for stopping lifts, which it may be well for those designing such pieces of apparatus to bear in mind. The suspension of lifts has been known to fail, and the whole has come down with a run, with disastrous or even fatal results. Several breaks or safety appliances have been proposed, but the best accident preventer seems to be the air cushion. A large lift was raised to full height, chairs and a table were arranged, a glass of water and an egg were placed upon the table, and the whole suddenly dropped, the air cushion arrangement being at the bottom. The whole came to a stop without any sudden shock, not even a drop of water being spilt, nor was the egg broken.

Rather Mixed.—A German contemporary, published in Berlin, but written in English, has this week, under the heading of "Industrial," the following extraordinary description of what is evidently a small motor, as follows: "A Diminutive Electrometer.—The firm Siemens and Halske has constructed a small electrometer, which in its most diminutive size is provided with ring-like fittings and has a diameter of about 30 centimetres and a height of 18 centimetres. It has a capacity of $^1/_{10}$ HP., the number of its revolutions per minute is 2500, while the expenditure of electric energy equals about 150 volt-amperes. In its smallest firm, this electrometer is most suitable for driving sewing machines, lathes, etc., but above all for working a silently-moving ventilator, specially constructed for this purpose by the firm, which transports 40 cbm. of air per hour."

Death by Electricity.—According to Dr. Robert Amory, who writes in the *Electrical World*, death is not caused by the shock itself, but results, as in hanging, from asphyxia. "It will be evident that if a living body is held between two conductors of opposite potentials of electrical condition, and receives the full current between a very high electrical potential to a very low potential, and cannot be extricated in time, the animal functions of muscular contraction are thrown into a strong tonic spasm, which will prevent the free respiratory movements which are essential to life. If these conditions are maintained for a sufficient period of time, the natural movements of respiration are delayed long enough to suspend the movements of blood in the capillary circulation. Thus the tissues are paralysed, and oxidation of the blood ceases, and in consequence the blood ceases to stimulate the heart to action."

Machines for Copper Wire.—It is recorded that Mr. H. A. Williams, of the Williams Manufacturing Company, of Taunton, Mass., has invented a machine for cheapening and improving steel or iron wire, which will probably make a change in many branches of industry in which wire is used. The invention consists of a series of rolls in a continuous train, geared with a common driver, each pair of rolls having a greater speed than the pair preceding it, with an intervening friction clutch adapted to graduate the speed of the rolls to the speed of the wire in process of rolling. The entire process of manufacturing the smallest size wires from rods of ½in. is done cold. The new process obviates the danger of unequal annealing and of burning in the furnaces, and the wire is claimed to be more flexible and homogeneous than that produced by the common processes, and

capable of sustaining greater longitudinal strain. Copper wire made by this process is claimed to be possessed of greatly increased electrical conductivity. The Williams Wire Machine Company will manufacture the machines at Taunton, Massachusetts.

The Detection of Hot Bearings.—M. Gerboz has devised an apparatus which should prove of considerable use in central station work, by which an audible and visible signal is given to the engineer if any part of the machinery to which the apparatus is fitted should become unduly heated. In its simplest form, as applied to the crank-pin of a steam engine, the device consists of a small cylinder fastened to and projecting from the crank-pin, and containing a plug of easily fusible alloy, which is pressed against the end of the crank-pin by a perforated piston and spring. The piston-rod, by means of a lever, controls a catch belonging to the mechanism of a bell placed over the apparatus. The gear of the bell, which is actuated by spring power, is previously wound up by hand and locked by the catch. If the crank-pin should become heated, the fusible plug melts, thus allowing the piston to descend, thereby releasing the catch and sounding the bell. In addition to this audible signal a disc, hidden underneath the bell, is turned in such a position that a bright colour is seen through two holes in the disc of the bell.

Ipswich.—A model installation has just been completed at Messrs. G. Mason and Co.'s oil mills, by Messrs. Paris and Scott, of Norwich. The details were arranged with Mr. Heaphy beforehand, the risk in oil mills being considerable, and special precautions have been adopted throughout. The plant consists of a Tangye engine of 10 h.p., fitted with a Turner-Hartnell governor. This engine drives one of Messrs. Paris and Scott's new patent "C" type dynamos, which generates the electric current carried direct to each building by six cables; the seventh cable charges a set of 13 accumulators to supply the lamps in the warehouse when the engine is not running. In the works are three lamps of 200 c.p. each, forty-seven of 16 c.p., and thirteen of 8 c.p. All the main and branch cables, which are of special make, are run in oak casing painted with cyanite paint, and provided with double-pole magnetic cut-outs, which break the circuit if from any cause 25 per cent. more than the normal current of electricity passes, and each lamp is also protected by a fuse. The installation has in every detail been thoroughly carried out, and is a model of what such an installation should be.

Royal Meteorological Society.—The concluding meeting of this society for the present session was held on Wednesday evening, the 20th inst., Dr. W. Marcet, F.R.S., president, in the chair. Among the papers was the "First Report of the Thunderstorm Committee." This report deals with the photographs of lightning flashes, some sixty in number, which have been received by the society. From the evidence now obtained it appears that lightning assumes various typical forms under conditions which are at present unknown. The committee consider that the lightning flashes may be arranged under the following types:—(1) stream; (2) sinuous; (3) ramified; (4) meandering; (5) beaded or chapletted; and (6) ribbon lightning. In one of the photographs there is a *dark* flash of the same character as the bright flashes, but the committee defer offering any explanation of the same until they get further examples of dark flashes. As the thunderstorm season is now coming on, the committee propose to publish their report at once, along with some reproductions of the photographs by the autotype process, in order that observers may be prepared to notice the various forms of lightning.

The Dynamicables.—What has become of the Dynamicables? It is a question many of our readers may have often asked. It was to be a social club for electrical engineers, an opportunity of meeting for those directly interested in electric light and power, and to set the tide for all affairs directly affecting the electrical engineering interests. But it seems to have been more or less swamped. The Boston Club is in a flourishing condition, with a fine building, and magnificent suites of rooms for meeting, dining, and conversation, fitted with electric light and all the newest appliances, the door even opens by itself by electricity as you enter, and a feeling of good fellowship and of commercial usefulness is apparent. Where is the analogue of this in London? Apart from the strictly proper and highly scientific circles of the Telegraph-Engineers, it was easily seen that some other means of meeting and discussion were required, and the Dynamicables were to fill this field. We do not think it can be said that they have hitherto done this; but, perhaps, better times are in store. A feeling of activity is moving amongst them, and it wants one or two real live men, with the good interest of electrical circles at heart, to take the initiative for this amiable and talented society to make its influence felt.

Terni.—Our Italian electrical contemporary furnishes particulars of an interesting central station at Terni, which has been running since February last. The number of lamps at present in use is 350, of 16 and 50 c.p., distributed over a distance of 2½ miles. The central station is situated away from the town; the system in use being with Zipernowski transformers. The primary wires are seven millimetres in diameter, run overhead, and are not insulated. The generating plant consists of three sets of machines, one being for reserve. Each set consists of a 150 h.p. Gerard turbine, with a Zipernowski alternate current dynamo of 40 amperes and 2,000 volts, driven at 250 revolutions per minute, with a separate exciter giving 60 amperes continuous current at 100 volts. Each set of generators will feed 1,000 16-c.p. lamps; so that, including the reserve, the installation will be sufficient for 3,000 lamps. The regulation is effected by means of six resistances, so arranged as to set in motion and connect a second dynamo when necessary. The primary current is transformed at the town itself by means of 21 Zipernowski-Deri-Blathy transformers of 7,500 volt-amperes, which feed into different secondary circuits, maintaining a constant pressure of 100 volts. The installation was completed in ten months by Ganz and Co. for the "Societa della Valnerina di Terni."

Spanish Theatres.—The Spanish Government having rendered the lighting of the theatres compulsory, great efforts have been made to satisfy this obligation. The first theatre to complete its lighting on the new system is La Comedia Theatre of Madrid, where 450 incandescent lamps have been installed. Collet tubular boilers are used, with one quick-speed vertical engine and two Schuckert dynamos, giving 75 amperes at 105 volts. The management, however, got into hot water on account of the noise made by the machinery, to which the neighbouring tenants strongly object. The space available for machinery is very limited, and the installation cannot be said to be as silent as it might be. An injunction has been granted by the authorities, and the theatre, not being allowed gas, has had to fall back upon the primitive candle. Meanwhile they are still under the commands of the Government to

be properly lighted by electric light by September next. We understand that it is very probable an English company will receive some of the orders for lighting other Spanish theatres, and these installations will, we are sure, prove satisfactory. The Spanish are a peculiar nation on business matters, and should have laid their plans better in the first instance. It might be preferable, on all accounts, if the distribution were effected from a central station, with machinery in an unobjectionable place, instead of the complete upheaval of every theatre and public building in Madrid to fix a steam-engine and boilers. As gas is at nine shillings a thousand, there is evidently an opening in the town for an electric light company.

Carbon Electrodes.—In an article on "Carbon Electrodes for Secondary Cells," in the *Electrical World*, Mr. A. V. Meserole says: "Carbon has been considered an ideal substance for secondary battery electrodes, on account of its constant conductivity and indestructible nature. Common battery carbon is not at all suitable for this purpose, probably on account of the foreign matter usually combined with it. Electrodes composed of mineral or gas carbon will not absorb or retain enough electrical energy to be of any practical use in a secondary battery. There is always some local action, and when a charging current is passed through the cell large quantities of sulphuretted hydrogen gas are set free. A very fair secondary cell, however, may be made, with carbon as an active absorbent, by using certain vegetable carbonised substances, such as bamboo, boxwood, and the like, which form good conductive carbon. This may be pulverised and mixed with variable proportions of graphite, and pressed into porous pots or bags. The material should be worked into a paste with acidulated water, and then compressed within the porous retaining envelope along with a number of conducting plates or rods composed of an alloy of lead and antimony, amalgamated with mercury. The usual grid also may be filled in with this plastic material, and then closely wrapped with asbestos tape or cloth to prevent washing out. The addition of oxide of lead to the mass, forming one electrode, will increase the capacity of the element, and so would the addition of oxides of various other electro-negative and electro-positive metals to the respective secondary poles. The addition of any quantity of metal or oxide would, of course, introduce objections which the use of carbon alone is intended to avoid. The use of a pure carbon grid containing a pure carbon active absorbent would be preferable in many respects. It would have a constant conductivity, would be practically indestructible, and would permit the use of any desired electrolyte, which may be the key to future improvements in secondary batteries."

A New Form of Galvanometer.—A new form of galvanometer, whose action depends upon the variable degree of expansion under the influence of heat of different metals, has been proposed. This device is well known and employed largely as a thermostat. The objection to the use of such a device in instruments of any delicacy is that they must be adjusted according to the temperature in which they are used, or some compensation must be made for the differences of position or deflection which varying temperatures cause. Dr. W. E. Geyer and Mr. W. H. Bristol, of the Stevens' Institute of Technology, Hoboken, New Jersey, have introduced a form of galvanometer on this principle, whose indication is entirely independent of the surrounding temperature. A compound arm or bar is employed consisting of but a single metal, the two arms of the bar being joined at one end, but insulated from each other through their length. These two arms are made of such relative shape and size as to be differently heated and expanded by a current of the same strength passing in series through each. The compound bar consists of a wide strip of metal (of german silver, for instance), and of a wire of the same metal. These two pieces of metal are insulated from each other, and their free ends are connected to the binding posts, near which also they are firmly held in place so as to prevent movement at that end. A given current passing through the strips in series will raise the temperature of the wire more than the strip on account of the greater radiating surface of the latter, and the wire expanding more than the strip bends or deflects the bar, which will tend to straighten out. The gearing of the pointer on the scale is so arranged that the deflections of the pointer shall be in direct proportion to the strength of the current passing through the compound bar. Both parts of the bar are equally and similarly affected by any external changes of temperature, therefore the apparatus is independent of the surrounding temperature; and as the indication is effected by the heating effect of the current, the instrument is adapted for alternating currents as well as continuous, and in connection with suitable clockwork may act as a current register or meter.

Manchester Botanical Gardens.—The Botanical Gardens, Old Trafford, Manchester, which formed part of the late Royal Jubilee Exhibition, have been rendered more attractive by the Corporation, and have been lighted by electric light by the Manchester Edison-Swan Company, Limited. Fifty-six 2,000 c.p. arc lamps are used. The combined boiler and engine has been constructed by Messrs. Marshall, Sons, and Co., Limited, Gainsborough, and was erected by Messrs. J. B. Welch and Co., Market-street, Manchester. It is provided with Hartnell's automatic expansion valve gear, by which great regularity in speed is attained, even under considerable and frequent variation of load. The engine runs at a speed of 120 revolutions a minute, and is capable of indicating 130 h.p. Two shunt-wound dynamos, specially constructed for this work by Messrs. Elwell-Parker, Limited, Wolverhampton, are used, capable of supplying forty 10 ampere arc lamps each. Switches and resistances, together with a current indicator, are fixed in the engine-room. The arc lamps used in this installation are a new and neat type of lamp—the invention of Messrs. Phillips, Harrison, and Hart. The regulating apparatus is very simple and not liable to get out of order, and the light is very steady. The building which formed the main approach to the late Exhibition has been converted into a dining-room, promenade, and concert-room, which are lighted by 24 arc lamps. The remaining 32 arc lamps are distributed in the grounds, and are fixed to masts. Overhead wires are used, which are hardly preceptible. The installation works very well, though a humming sound caused by the exhaust steam was noticeable, which was audible in the concert-room, and ought to be remedied. This arc light installation is the largest the Manchester Edison-Swan Company have as yet erected, their usual work being incandescent lighting, but in future they intend to devote more attention to arc lighting. The whole of the arrangements in connection with the electric lighting have been carried out by Mr. J. R. Williamson, A.M.I.C.E., managing director of the Manchester Edison-Swan Company, and to his personal superintendence and unremitting exertions is due the success which has attended this most important installation of the arc light in the district.

ELEMENTARY TESTING SUITABLE FOR ELECTRIC LIGHTING SYSTEMS.

BY THOMAS GRAY, B.SC., F.R.S.E.

(*Continued from page 534.*)

INSTRUMENTS FOR THE MEASUREMENT OF ELECTRIC CURRENTS.

The instruments which may be included under this heading have become within the last few years very numerous. For our present purpose it is necessary that the general principles on which the proper construction of such instruments depends should be stated, and that a few examples of the different types should be described. Under the head of instruments for the measurement of currents, it will be convenient to include that class of voltmeters the indications of which depend on the current passing through them. The instruments now most used in the practical applications of electricity almost uniformly lay claim to be designated measurers in absolute units; but previous to this state of things there existed many valuable instruments, the indications of which depended on electric currents, which, in comparison with the more modern class, may perhaps be properly called galvanoscopes. They have generally been called galvanometers, and, as they have already been frequently referred to, are largely used, and are the most suitable, for the comparison of resistances and similar experimental work, a description of them will be taken first.

Galvanometers.—These instruments originated with the discovery and publication by Oersted of the action of a wire through which a current of electricity is passing on a magnetic needle. If the needle be pivoted or suspended in such a way as to be free to move, and a wire conveying an electric current be brought near to it, the needle tends to turn so as to place its length at right angles to that of the wire.

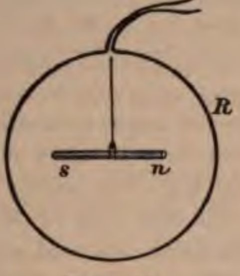


Fig 23.

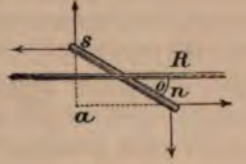


Fig 24.

The direction, relatively to that of the current, in which the needle will move is of considerable importance in some cases, and several rules have been enunciated for the guidance of experimenters. The following is perhaps as simple and easily remembered as any other. Suppose the earth's magnetism to be due to a permanent magnet in its centre, which has been turned into position by currents round the earth's equator, then the direction of the current round the earth would be the same as that of the sun's motion. If, then, we suppose a magnetic needle suspended with its length horizontal and free to turn round a vertical axis, it will always be turned by a current towards such a position that, to an observer looking at the *true north* end of the magnet, the currents will pass from left to right over the magnet, or from right to left under it. By the *true north* end of the magnet is meant the end at which the corresponding magnetic pole to the north magnetic pole of the earth is situated that is, the "south-seeking" pole of the needle. The force with which the needle is urged towards this position is proportional to the magnetic moment of the needle, to the strength of the current through the wire, to the number of times the wire passes over or under the needle, and to the proximity of the wire to the needle. Probably the earliest form of galvanometer was Schweigger's multiplier, which was invented in 1820, shortly after the publication of Oersted's discovery. It consisted of a magnetic needle, pivoted in the centre of a rectangular coil of wire, through which the current was passed. The object of this invention was to obtain sensibility by passing the current several times round the needle, and the rectangular form was evidently intended to bring the wire near the needle, while at the same time its length could be in the central plane of the coil, or the position of maximum turning couple. The rectangular form of coil is still much used, especially in galvanometers provided with needles of considerable length. The more common form for the coil in the instruments now used for accurate work is a circular ring of approximately rectangular cross section. The action of a circle of wire conveying an electric current on a magnetic needle hung within it will be more readily understood by reference to Figs. 23 and 24, which show a plan and elevation of a ring and needle. The needle, $s\,n$, is suspended with its length horizontal near the centre of the ring, R, which is supposed to be fixed with its plane vertical and parallel to the equilibrium position of the length of the needle, $s\,n$, when no current is flowing through the ring. When a current is made to flow through the ring in the direction of the arrows, the needle turns into some such a position as that indicated in the figure, the exact position being determined by the strength of the current and the strength of the magnetic-field in which the coil and needle are placed. Let the strength of current through the coil be C, and the strength of the field, or force with which a unit magnetic pole is acted on in the field, be H. Then, if the strength of each pole of the needle be m, the distance between the two poles l, and the angle which the length of the needle makes with the plane of the coil θ, we have equlibrium between the couples $A\,C\,m \times n\,a$ and $H\,m \times s\,a$. But $n\,a = l$ cos. θ, and $s\,a = l$ sin. θ, hence $A\,C\,m\,l$ cos. $\theta = H\,m\,l$ sin. θ, or

$$C = \frac{H}{A} \tan.\ \theta.$$

The multiplier, A, introduced into these equations is a constant which depends on the size and number of turns in

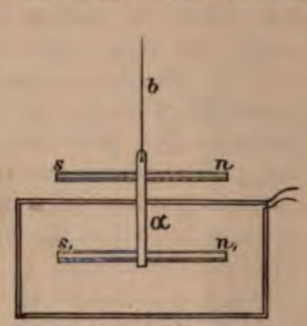


Fig 25

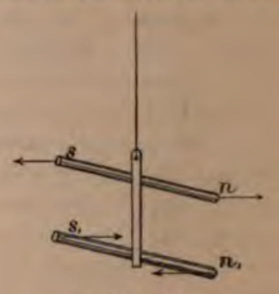


Fig 26.

the coil or ring, R. The force on the poles of the needle due to the current in the ring is here supposed to be at right angles to the plane of the ring, which is only accurately the case when θ very small, or when the needle is very short compared with the diameter of the ring, or when a coil is used consisting of a number of rings arranged to form a solenoid, the length of which is great compared with the diameter of the rings. In sensitive instruments, it is desirable that the diameters of the rings of wire forming the coil should be small, and also that the coil should be short—that is to say, the whole of the turns of wire forming the coil should be brought as close to the needle as possible. This condition is inconsistent with the production of a uniform magnetic field round the needle; and hence, if the tangent law is to be used, it is important that the maximum deflection of the needle be small. The best instruments of this class are Thomson's mirror galvanometers, which will be more particularly described presently. The difficulty as to the want of uniformity in the magnetic field produced within the coil around the needle can, of course, be got over by determining experimentally the deflections produced by measured currents of different strength and in this way calibrating the instruments. This device is very commonly resorted to with instruments for the measurement of large current or high potentials — amperemeters and voltmeters—and methods of performing the calibration will be described further on.

An improved form of multiplier was invented in 1825 by

Nobili, who introduced a second magnetic needle of opposite polarity to the first into the instrument. The arrangement of the coil and needles in Nobili's multiplier is illustrated in Fig. 25. Two magnetic needles, sn and n_1s_1, are attached to a rigid rod or frame, a, and either pivoted or suspended by a fine wire, b, so as to hang with their length horizontal, and to be free to turn in azimuth. The lower needle is placed in the middle of the multiplier coil, c, and the upper needle slightly above the upper edge of the coil. It is clear from what has been said above as to the direction in which a magnet is turned by a wire conveying an electric current, that the effect of passing a current through the coil, c, will be to turn both needles in the same direction, and hence, other things being the same, greater sensibility will be obtained by the double needle arrangement. The great importance of the double needle system lies, however, in the fact that while the total effect of the coil on the needle system is the sum of its effects on the separate needles, the couple acting on the deflected needle system produced by the magnetic field in which the instrument is placed, and which balances that produced by the coil, depends not on the sum but on the difference of the couples acting on the separate needles. This is illustrated in Fig. 26, which shows a perspective view of the double needle, supposed in this case to be suspended by a fibre of negligible rigidity. The directions of the forces on the needles are indicated by the arrows in the figure. Let the strength of each magnetic pole of the needle sn be m, and the distance between the poles l; let the corresponding quantities for the needles $n_1\,s_1$ be m_1 and l_1; and let θ be the angle which the length of both needles makes with the direction of maximum horizontal force H in the magnetic field. The couple acting on the needle $s\,n$ will be H $m\,l$ sin. θ, and

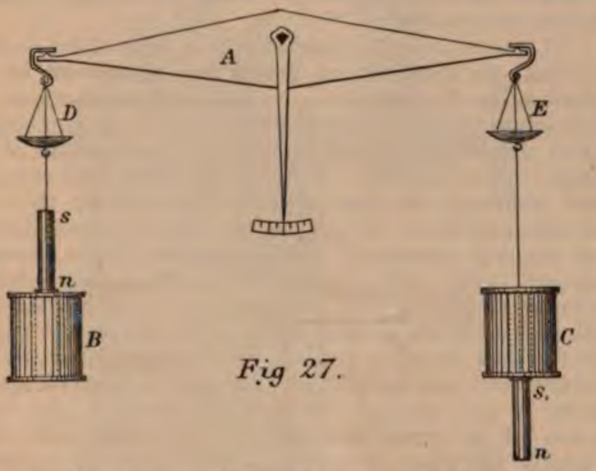


Fig 27.

the couple acting on the needle $n_1\,s_1$ will be $-$ H $m_1\,l_1$ sin. θ. Hence, the total couple acting on the system is $(m\,l - m_1\,l_1)$ H sin. θ. But $m\,l$ and $m_1\,l_1$ are the magnetic moments of the needles $s\,n$ and $n_1\,s_1$ respectively. Hence, it appears that if the two needles have equal magnetic moments, there will be no couple acting on the needle due to the magnetic field, and, in consequence, the needle system would turn so as to set the lengths of the needle at right angles to the planes of the coil when a current, no matter how small, is passed through the coil. When the needle system is in this condition it is said to be *astatic*. That is to say, when it is placed in a uniform magnetic field, it will be in equilibrium in any azimuth. The magnetic moments of the two needles are never absolutely equal; but the arrangement is always more sensitive than a single needle placed in the same magnetic field. A perfectly astatic system has another advantage—namely, that a change either of strength or direction of the force in the uniform magnetic field produces no deflection of the needles, and no change of sensibility. The directive force for such a case is obtained by placing a permanent magnet in such a position near the needles that it produces a somewhat stronger field at one needle than at the other. It generally happens in actual practice, however, that the system is not nearly astatic, and sensibility is obtained by producing a field of such different strengths at the two needles that it is nearly astatic. Under these circumstances, however, the so-called astatic system is sometimes particularly sensitive both to change of strength and change of direction of the uniform part of the controlling field, and hence astatic galvanometers are generally subject to troublesome changes in their zero of deflection, and also in their sensibility.

Another form of instrument for the measurement of electric currents was invented by Becquerel in 1837, and is illustrated in Fig. 27. It consisted of an ordinary weighing balance, A, from the scale pans, D and E, of which were suspended two bar magnets, $s\ n$ and $s_1\ n_1$, which were acted on by two coils of wire, B and C, through which the current was passed. The current was generally made to flow through the coils in such a direction as to repel both magnets, and the force was measured by putting weights on the scale pan D. This form of balance was never much used, but it is interesting as an easy example of a species which took advantage of the force with which a coil of this form tends to move a magnetic pole along its axis. Very similar principles are involved in some modern instruments.

About this time also the sine and the tangent compasses, since so much used for absolute measurements, were invented by Rouillet, and among others of the earlier workers in the improvement of instruments for the measurement of electric currents, the names of Poggendoff, Gauss, Weber, Helmholtz, Wheatstone, Joule, and Thomson are prominent. We shall next consider some examples of the instruments now in general use.

(To be continued.)

THE TESLA ALTERNATE CURRENT MOTOR.

The interest taken in M. Tesla's contributions to electrical apparatus and to electrical literature is so great, and the subject is so important, that we do not hesitate to give further space to the subject. On May 26 a communication on the subject from Dr. Louis Duncan, of Johns Hopkins University, appeared in our American contemporary, the *Electrical Review*, to the following effect:

"We may, for our present purposes, divide motors into two classes: Continuous, in which the armature coils are unsymmetrical with respect to the poles, and which, therefore, give a practically constant torque, and alternating motors, in which the armature coils are symmetrical with respect to the poles, and which, therefore, give a torque varying both in magnitude and sign during a period of the counter E.M.F. The Tesla motor belongs to this latter class.

"In every motor the torque is equal to the rate of change of lines of induction through the armature circuit for a small angular displacement, multiplied by the armature current, or

$$\frac{dm}{dt}\,\mathrm{I}.$$

In the Tesla motor the first of these terms is greatest when the coil is opposite a pole and the field currents have their greatest amplitude. It is zero at a point about 45deg. from this, supposing we neglect armature reactions. It depends on several things. The E.M.F. which determines it is due to changes in the number of lines of force passing through the armature circuit caused by (1) changes in the field currents; (2) the motion of the armature. The current depends on these E.M.F.'s, and on the reduced self-induction and resistance of its circuit. The motor can only do work when the first cause of E.M.F. is the greater, for a current in the direction of the ordinary counter E.M.F. would stop the motion. In some parts of a revolution the two E.M.F.'s work together, retarding the motion; in others, the induced E.M.F. produces a current causing the motor to revolve. It is impossible for me, with only a meagre description of the principles of the machine, to give an idea of the relative magnitudes of these effects. Some of the results, however, are the following: Having given a definite number of reversals of the dynamo, there are a number of speeds, multiples of these reversals, at which the motor will govern itself when it is doing a certain amount of work. At one of these speeds, depending on the construction of the motor, the output will be a maximum.

Now I see the statement that 'there is no difficulty whatever attendant upon starting the motor under load.' I cannot reconcile this with above facts. That the torque for a smaller number of revolutions than ordinarily used, might be greater, one can readily see, since the counter E.M.F. is less in proportion to the induced E.M.F., but it must be remembered that for certain speeds even the induced current would tend to stop the motion; how the motor is to pass these critical speeds I do not see. Again, if the maximum load is suddenly thrown on while the motor is running at its proper speed, then, if the inertia be great, the motor will fall behind its point of maximum work, and either stop or take up some slower speed.

"What the possible efficiency and output of the motor may be, only experiment can tell. I have shown* that the output of an ordinary alternating motor is equal to that of a continuous current motor, supplied with a corresponding E.M.F. The efficiency might be great, but it has the disadvantage that about the same current flows for no work and maximum work, so for light loads the efficiency can hardly be very high.

"With our present knowledge of alternating currents it is useless to attempt to calculate from the simple though misleading assumptions ordinarily made, the output, conditions of maximum work, &c., of this machine. Experiment alone can determine its value, and one properly conducted and interpreted set of experiments should enable us to judge both the merit of the invention and its best possible form. I cannot see, however, how, in the form described in the last issue of this journal, the motor can work under conditions of a suddenly varying load as satisfactorily as continuous current motors."

To the above Mr. Tesla replied on June 2 as follows:

"I find in your issue of last week a note of Mr. Duncan referring to my system of alternate current motors.

"As I see that Dr. Duncan has not as yet been made acquainted with the real character of my invention, I cannot consider his article in the light of a serious criticism, and would think it unnecessary to respond; but desiring to express my consideration for him and the importance which I attach to his opinion, I will point out here briefly the characteristic features of my invention, inasmuch as they have a direct bearing on the article above referred to.

"The principle of action of my motor will be well understood from the following: By passing alternate currents in proper manner through independent energising circuits in the motor, a progressive shifting or rotation of the poles of the same is effected. This shifting is more or less continuous according to the construction of the motor and the character and relative phase of the currents employed, and I have indicated the theoretical conditions which should exist in order to secure the most perfect action.

"If a laminated ring be wound with four coils, and the same be connected in proper order to two independent

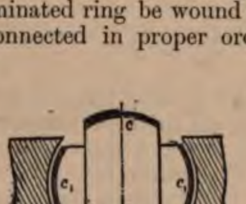


Fig. 1.

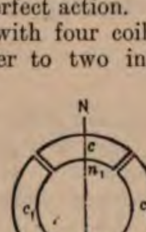


Fig. 2.

circuits of an alternate current generator adapted for this purpose, the passage of the currents through the coils produces theoretically a rotation of the poles of the ring, and in actual practice, in a series of experiments, I have demonstrated the complete analogy between such a ring and a revolving magnet. From the application of this principle to the operation of motors, two forms of motor of a character widely differing have resulted—one designed for constant and the other for variable load. The misunderstanding of Dr. Duncan is due to the fact that the prominent features of each of these two forms have not been specifically stated. In illustration of a representative of the second class, I refer to Fig. 1, given herewith. In this instance, the armature of the motor is provided with two coils at right angles. As it may be believed that a symmetrical arrangement of the coils with respect to the poles is required, I will assume that the armature is provided with a great number of diametrically wound coils or conductors closed upon themselves, and forming as many independent circuits. Let it now be supposed that the ring is permanently magnetised so as to show two poles (N and S) at two points diametrically opposite, and that it is rotated by mechanical power. The armature being stationary, the rotation of the ring magnet will set up currents in the closed armature coils. These currents will be most intense at or near the points of the greatest density of the force, and they will produce poles upon the armature core at right angles to those of the ring. Of course there will be other elements entering into action which will tend to modify this, but for the present they may be left unconsidered. As far as the location of the poles upon the armature core is concerned, the currents generated in the armature coils will always act in the same manner, and will maintain continuously the poles of the core in the same position, with respect to those of the ring in any position of the latter, and independently of the speed. From the attraction between the core and the ring, a continuous rotary effort, constant in all positions, will result, the same as in a continuous current motor with a great number of armature coils. If the armature be allowed to turn, it will revolve in the direction of rotation of the ring magnet, the induced current diminishing as the speed increases, until upon the armature reaching very nearly the speed of the magnet, just enough current will flow through the coils to keep up the rotation. If, instead of rotating the ring by mechanical power, the poles of the same are shifted by the action of the alternate currents in the two circuits, the same results are obtained.

"Now compare this system with a continuous current system. In the latter we have alternate currents in the generator and motor coils, and intervening devices for commutating the currents, which on the motor besides effect automatically a progressive shifting or rotation of the poles of the armature; here we have the same elements and identically the same operation, but without the commutating devices. In view of the fact that these devices are entirely unessential to the operation, such alternate current system will—at least in many respects—show a complete similarity with a continuous current system, and the motor will act precisely like a continuous current motor. If the load is augmented, the speed is diminished and the rotary effort correspondingly increased, as more current is made to pass through the energising circuits; load being taken off, the speed increases, and the current, and consequently the effort, is lessened. The effort, of course, is greatest when the armature is in the state of rest.

"But, since the analogy is complete, how about the maximum efficiency and current passing through the circuits when the motor is running without any load? one will naturally inquire. It must be remembered that we have to deal with alternate currents. In this form the motor simply represents a transformer, in which currents are induced by a dynamic action instead of by reversals, and, as it might be expected, the efficiency will be maximum at full load. As regards the current, there will be—at least, under proper conditions—as wide a variation in its strength as in a transformer, and, by observing proper rules, it may be reduced to any desired quantity. Moreover, the current passing through the motor when running free, is no measure for the energy absorbed, since the instruments indicate only the numerical sum of the direct and induced electromotive forces and currents instead of showing their difference.

"Regarding the other class of these motors, designed for constant speed, the objections of Dr. Duncan are, in a measure applicable to certain constructions, but it should be considered that such motors are not expected to run without any, or with a very light, load; and, if so, they do not, when properly constructed, present in this respect any more disadvantage than transformers under similar conditions. Besides, both features, rotary effort and tendency to constant speed, may be combined in a motor, and any desired preponderance may be given to either one, and in this manner a motor may be obtained possessing any

* Inst. Elec. Engineers, February, 1888.

desired character and capable of satisfying any possible demand in practice.

"In conclusion, I will remark, with all respect to Dr. Duncan, that the advantages claimed for my system are not mere assumptions, but results actually obtained, and that for this purpose experiments have been conducted through a long period, and with an assiduity such as only a deep interest in the invention could inspire; nevertheless, although my motor is the fruit of long labour and careful investigation, I do not wish to claim any other merit beyond that of having invented it, and I leave it to men more competent than myself to determine the true laws of the principle and the best mode of its application. What the result of these investigations will be the future will tell; but whatever they may be, and to whatever this principle may lead, I shall be sufficiently recompensed if later it will be admitted that I have contributed a share, however small, to the advancement of science."

STEAM CYLINDER LUBRICATOR.

We herewith illustrate a lubricator manufactured by the Steam Cylinder Lubricator Company, of Manchester. The large use of steam-power in electrical work necessitates a knowledge not only of electrical apparatus, but also of steam and gas engines and their accessories. Figs. 1 and 2 show this lubricator. In the sectional view, Fig. 2, A is the oil chamber in which works a steam-tight piston B, packed with asbestos, having screwed into its top side a hollow steel piston rod K, which works through a stuffing box. This piston rod also serves as an indicator showing the level of the oil. At the top end of the rod is a filling plug J, through which the oil is delivered into the chamber A, the oil passing through the small holes at the bottom of the tube, D is the steam inlet, H the connection to the cylinder, G the sight feed, L an air valve, M a plug which can be unscrewed and the sight feed G inserted, if required, at the other side, E is a run-off valve, and C is the base to which the lubricator is fixed.

The method of working is as follows. When the piston B is at the bottom, and the chamber filled with oil, steam is admitted through the pipe D by opening the lower valve to the under side of the piston, the area of which is larger than the top side by the amount of the area of the rod K. This difference of area causes the piston to be raised within the cylinder, and so displaces the oil above, which finds its way out to the engine steam pipe or chest through the upper valve F, past the sight-feed G and the connecting pipe H. The quantity of oil displaced can be readily regulated by adjusting the outlet valve to give any desired quantity.

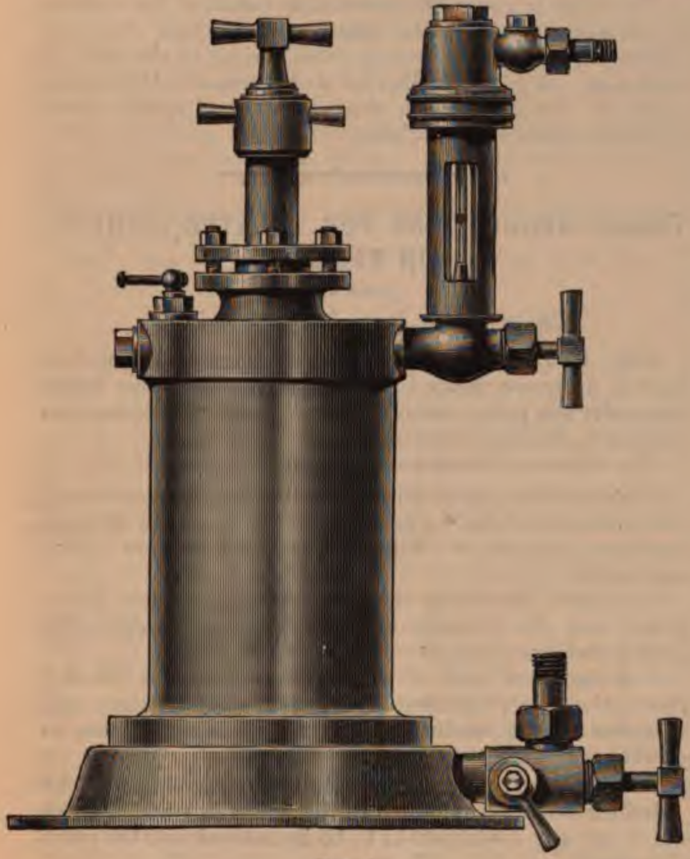


Fig. 1.

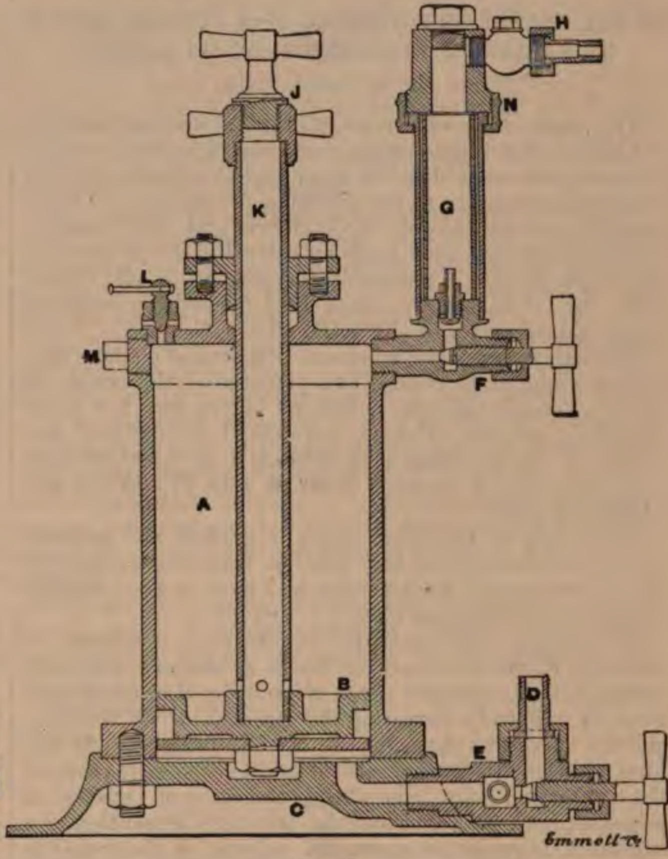


Fig. 2.

THE MINIMUM POINT OF CHANGE OF POTENTIAL OF A VOLTAIC COUPLE.*

BY DR. G. GORE, F.R.S.

In this communication is described the following very simple method of detecting the influence of the minimum proportion of chlorine, or other soluble substance, &c., upon the electromotive force of a voltaic couple (*Nature*, vol. xxxviii., p. 117).

Take a voltaic couple composed of an unamalgamated strip of zinc or magnesium (the later is usually the most sensitive) and a small sheet of platinum, immersed in distilled water, balance its electric potential through an ordinary galvanometer of about 100 ohms resistance by that of a precisely similar couple, composed of portions of the same specimens of the same metals immersed the same moment as the other pair in a separate quantity of the same water, and gradually add to one of the two cells sufficiently small and known quantities of an adequately weak solution of known strength in a portion of the same water, of the substance to be used, until the balance is upset, and take note of the proportions of the substance and of the water then contained in that cell. In the present experiments a magnesium-platinum couple was employed.

The minimum proportions required with several substances were as follows: Potassic chloride, between 1 part in 3,875 and 4,650 parts of water, potassic chlorate between 1 in 4,650 and 5,166, hydrochloric acid between 1 in 516,666 and 664,285, and with chlorine between 1 in 15,656,500,000 and 19,565,210,000.

The proportion required of each different substance is dependent upon very simple conditions—viz., unchanged composition of the voltaic couple, a uniform temperature, and employing the same galvanometer. The apparently

* Abstract of Paper read before the Royal Society, June 14, 1888.

constant numbers thus obtained may probably be used as te ts of the purity or of the uniformity of composition of dissolved substances.

The "minimum-point" varies, with—1st, the chemical composition of the liquid; 2nd, the kind of positive metal; 3rd, to a less degree with the kind of negative metal; 4th; the temperature at the surface of the positive metal and at that of the negative one; and 5th, with the kind of galvanometer employed.

The order of the degree of sensitiveness is manifestly related to that of the degree of free chemical energy of the liquid, also to the atomic and molecular weights of the dissolved substances, and to the ordinary chemical groups of halogens. The greater the degree of free chemical energy of the dissolved substance, and the greater its action upon the positive metal, the smaller the proportion of it required to change the potential.

As the "minimum point" of a chemically active substance dissolved in water is usually much altered by adding almost any soluble substance to the mixture, measurements of that point in a number of liquids at a given temperature with the same voltaic pair and galvanometer will probably throw some light upon the degree of chemical freedom of substances dissolved in water.

ON THE CHANGE OF POTENTIAL OF A VOLTAIC COUPLE BY VARIATION OF STRENGTH OF ITS LIQUID.*

BY DR. G. GORE, F.R.S.

This paper contains a series of tables of measurements of the E.M.F. of a voltaic couple composed of unamalgamated zinc and platinum in distilled water, and in aqueous solutions of different strengths of the following substances: Potassic chlorate, potassic chloride, hydrochloric acid, and bromine. The measurements were made by balancing the potential of the couple by that of a suitable thermo-electric pile (Birm. Phil. Soc. *Proc.*, vol. iv., page 130) through an ordinary astatic galvanometer of about 100 ohms resistance.

The following are the minimum proportions of those substances required to change the potential of the couple in water: Potassic chlorate, between 1 in 221 and 258 parts of water; potassic chloride, between 1 in 695,067 and 1,390,134; hydrochloric acid, between 1 in 9,300,000 and 9,388,185; and of bromine, between 1 in 77,500,000 and 84,545,000 parts.

With each of these substances a gradual and uniform increase of strength of the solution, from the weakest up to a saturated one, was attended by a more or less irregular change of electromotive force.

By plotting the quantities of dissolved substance as ordinates to the electromotive forces as abscissæ, each substance yielded a different curve of variation of electromotive force by uniformly increasing the strength of its solution, and the curve was characteristic of the substance. As the least addition of a foreign soluble substance greatly changed the "minimum point," and altered the curve of variation of potential, both the curve and the minimum proportion of a substance required to upset the balance of the couple in water may probably be used as tests of the chemical composition of the substance, and as means of examining its state of combination when dissolved. By varying the strength of the solution at each of the metals separately, a curve of change of potential was obtained for each positive metal, but not for every negative one.

INFLUENCE OF THE CHEMICAL ENERGY OF ELECTROLYTES UPON THE MINIMUM POINT AND CHANGE OF POTENTIAL OF A VOLTAIC COUPLE IN WATER.*

BY DR. G. GORE, F.R.S.

By means of a zinc platinum voltaic couple in distilled water, with its electro-motive force balanced by that of a suitable thermoelectric pile (Birm. Phil. Soc. *Proc.*, vol. iv., p. 130), the effect of several groups of chemical substances upon the potential of the couple was examined. Measurements were made of the electromotive forces of a series of strengths of solution of each substance, and the results are given in a series of tables.

* Abstract of Paper read before the Royal Society, June 14, 1888.

The minimum proportions of substance required to change the potential of the couple in water were as follows:—

Potassic iodate,	between	1 in	443	and	494
,, bromate	,,	1 ,,	344	,,	384
,, chlorate	,,	1 ,,	221	,,	258
Potassic iodide,	between	1 ,,	15,500	,,	17,222
,, bromide	,,	1 ,,	66,428	,,	67,391
,, chloride	,,	1 ,,	695,067	,,	704,540
Iodine,	between	1 ,,	3,100,000	,,	3,521,970
Bromine,	,,	1 ,,	77,500,000	,,	84,545,000
Chlorine,	,,	1 ,,	1,264,000,000	,,	1,300,000,000

On comparing these numbers we find that the proportion of substance required to upset the voltaic balance was largest with the oxygen salts, intermediate with the haloid ones, and least with the free elementary halogens. It was smaller the greater the degree of chemical energy of the substance, thus it was about 400 times less with chlorine than with iodine. And it was smaller the greater the degree of freedom to exert that energy; thus it was about 5,416,000 times less with free chlorine than with potassic chlorate, or 1,570,000 times less than with the combined chlorine of the chlorate; and about 185 times smaller than with potassic chloride, or 88 times less than with the combined chlorine of that salt.

The order or curve of variation of potential by uniform increase of strength of the solution was different with each substance, and was apparently characteristic of the body in each case. A great number of such representative curves might be obtained with a zinc platinum or other voltaic couple in different electrolytes.

POLICE REGULATIONS FOR THEATRE LIGHTING IN PARIS.

CHAPTER I.—*Preliminary Formalities.*

ART. 1. Every person wishing to install the electric light in a theatre, music hall, or other similar public building under the police authority, must make the declaration thereof to the Prefecture of Police.

The following details must accompany the notice :—

a. A detailed plan in triplicate indicating the positions of the generators, steam, gas, or air engines, the dynamo machines, batteries, accumulators, and the position of the conductors.

b. A note describing the engines, giving their horse-power, and the dynamos and lamps, arc or incandescent, giving their number and candle-power.

c. A sample of each of the conductors, with a detailed description of arrangement of the circuits, the nature and diameter of the conductors, and the current they are to carry.

ART. 2. The work cannot be commenced until the Administration have notified to the declarer whether there are or not any modifications to be introduced into the plans deposited.

ART. 3. The electric light will not be allowed to be put into ordinary use until after it has been favourably passed by the Superior Commission of Theatres, and until after a trial lighting has been made before the Technical Commission.

ART. 4. After reception of the machinery, no modification may be made in the installation without the same formalities.

CHAPTER II.—*Boilers, Engines, and Smoke Flues.*

ART. 5. Steam engines, gas engines, or air engines must not be placed in parts of the building accessible to the public or to the artistes. The engines must be fixed in such a manner as to afford thorough security against accidents.

ART. 6. The boiler furnaces and the fuel for the same must be placed in a separate locality, built in completely fireproof materials, with iron doors, and separated from the other parts of the establishment by walls of masonry, as well as by vault, or iron girders covered with bricks of a sufficient thickness.

These localities must be well arranged and properly ventilated, either naturally by air currents issuing away from the public ways, or by flues sufficiently isolated from the other parts of the establishment, or by mechanical means.

ART. 7. The fixing of the boilers must conform to the regulations of the public administration already in force.

ART. 8. The smoke flues must be in brick, of a width and section sufficient to carry the smoke of the furnaces to which they lead. They must always be fixed 16ft. (five metres) above the tops of the neighbouring chimneys.

These smoke flues must be placed at the exterior of the building, in the courtyards or areas, unless with special permission after notice to the Superior Commission of Theatres. In any case these chimneys must not produce dense or disagreeable smoke. Either efficacious smoke consuming apparatus must be used or smokeless fuel.

CHAPTER III.—*Batteries, Accumulators, and Dynamos.*

ART. 9. Electric batteries, or accumulators, must be placed in a special room, well ventilated, and where any noxious vapours are given off must be placed under a cover with chimneys for carrying off the gases and vapours to above the roof. The acids and other chemicals used for maintenance must be stored in a special compartment, and must never be within reach of strangers.

ART. 10. The dynamos must be placed in a dry position, not containing any inflammable matter, and protected from dust. They must be properly insulated, and kept always in good condition.

The installation must be perfectly secure in all respects. Special arrangements must be taken in the case of alternating currents.

The maintenance must be carried out by experienced superintendents and workmen.

Regulations and cautions must be posted up in a prominent position in the dynamo-room.

CHAPTER IV.—*Cables and Conducting Wires.*

ART. 11. All conductors in the engine-room must be solidly supported, well in view, marked, and numbered.

ART. 12. The switches employed to direct the currents must be manufactured with care, and mounted on incombustible insulating material.

ART. 13. A voltmeter and ampere-meter for each machine must be mounted in a firm position to control the currents.

ART. 14. A main fuse must be placed on each cable at its junction with the switchboard. Each branch main or sub-main must be equally protected with a fuse.

These fuses must be properly gauged, and must not allow a larger current to pass at the maximum than thrice that of the normal strength.

ART. 15. In every part of the circuit the diameter of the conductors must be so proportioned to the strength of the current, that it cannot produce at any point a degree of heating dangerous to the insulation of the conductors, or to objects in the vicinity.

ART. 16. For continuous currents, the difference of potential must not exceed 300 volts at the terminals of the machines, or at the entrance of the theatre, if the source of electricity is exterior.

With alternating currents, four arc lamps at the most may be placed in series, or a number of incandescent lamps corresponding to the same potential.

Exceeding these limits, special permission must be granted by the Superior Commission of Theatres.

ART. 17. The employment of water and gas pipes or metal fittings as conductors is rigorously forbidden.

ART. 18. The wires and cables must be covered with a material offering every guarantee as to quality of the insulation; at all times the loss in the conductors through defect of insulation must be less than one-thousandth of the current carried by them.

ART. 19.—Except in the vicinity of the lamps, all the wires and cables must be firmly fixed and kept a space of 10 millimetres ($\frac{3}{8}$in.) apart at the least for incandescent lamps, and of 20 millimetres ($\frac{3}{4}$in.) for arc lamps, the distance between the wires and pieces of metal of the building must be 60 millimetres ($1\frac{1}{2}$in.), unless the cable is covered with lead.

ART. 20. When the conductors go through floors, stairs, walls, or partitions, or when they cross each other, they must be protected by a second covering of some hard and incombustible material. In situations exposed to damp, or in going through walls, special precautions must be taken to protect the conductors.

ART. 21. All wires which will be within reach of the hands of the public, or of persons not belonging to the service, must be placed under easily recognisable mouldings.

CHAPTER V.—*Lamps.*

ART. 22. Naked lights are prohibited.

ART. 23. Arc lamps must be protected by glass globes or by lanterns. They must be provided with a wire net to catch sparks or pieces of glass.

ART. 24. Incandescent lamps of more than 30 c.p. must also be protected with a net.

ART. 25. Cables for suspending the lamps must be incombustible and independent of the conducting-wire. The said wires must never, in any case, serve for suspending the lamps.

CHAPTER VI.—*Passage Lighting.*

ART. 26. If the lighting of the passages is provided by the electric light, it must be assured by means of at least two independent batteries of primary cells or accumulators. In this case, the cables or wires conducting the current to the passage lamps must always be placed in front of the drop scene; and, further, these batteries must always be charged before the period of performance. During the period of performance the batteries must be completely disconnected from the dynamos.

The switches for connecting the batteries of accumulators to the dynamos must be placed in an open and easily accessible place, and must be provided with a plan indicating clearly the arrangement adopted for disconnecting the dynamos during the period of performance.

The batteries of accumulators or primary cells must each feed to an upright, placed one near the entrance hall and the other the pit; the branches from these uprights must cross at each landing, so that at each landing the successive passage lamps may be fed alternately, the one by the stage battery, and the next by that of the pit.

In the direction of each exit there must be placed a lamp bearing a special mark, which, for these installations, may consist of a double-power lamp, or two lamps in conjunction.

Further, all passage lamps must throughout bear a special mark, to enable those in charge to exercise an easy supervision over the lighting of the passages of all theatres.

The passage lamps must always be at least equal to five c.p.

CHAPTER VII.—*General Arrangements.*

ART. 27. From the date that the installation of the electric light in the theatre has been passed by the Superior Commission, all communication with the gas companies' mains must be cut off.

ART. 28. Theatres, music-halls, and other similar public buildings already lighted with electric light whose installations do not conform to the present ordinance, must satisfy the same within a period of six months.

ART. 29. Article 39 of the ordinance of 16th May, 1884, and the whole of the ordinance of 21st February, 1887, and also any other ordinance contrary to the present, are hereby rescinded.

ART. 30. The present ordinance must be printed, distributed, and posted up in Paris, and in the various police stations.

Everyone whom it may concern, the Chief of the City Police, the Principal of the City Laboratory, the Commissioners of Police, and other officers of the Prefecture of Police, are charged to see that this ordinance is carried out.

The Colonel of the Sapeurs-Pompiers is requested to assist therein.

H LOZÉ, *Prefect of Police.*

THE

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

PATENTS.

It used to be supposed that a patent, in order to be valid, must possess some originality; but it may, perhaps, be taken for granted that the only danger in the path of a patent now is, that it may be disputed. Almost anything can be patented, and if it is worth nobody's while to dispute the patent, it remains and runs the usual course. We have been somewhat surprised to find the most eminent authorities advising that, for example, a patent to use motors on tramways in series controls all patents for series tramway work. Now, so far as we know, there are only three ways of working, series, parallel or multiple series, and, according to the legal wisdom, anyone patenting one or other, or all these systems, will control electric traction wholly or in part. If electric traction or transmission of power is possible, it is possible in these three ways, and this fact is well known to every schoolboy who dabbles in electrical matters. Surely, the mere fact that a man embodies this common knowledge in a patent should not be sufficient to give him a legal status whereby he can stop any other person using apparatus that it is well known can be used in these ways. Can a man patent the driving of a tramcar with one horse, or with two, three or more abreast, or two, three or more tandem fashion? Everybody knows that a carriage or tramcar can be so moved, and certainly, according to the dicta of those learned in the law, a patent taken out to the above effect in the early days of tramway work would have controlled the whole system, except, indeed, that some other wise individual would have patented traction by means of mules or donkeys. Till quite recently the engineers who have had most experience in tramway work have more or less held aloof from active participation in the schemes for the application of electricity to such work, but we are only stating open secrets by saying that one or two exceedingly strong syndicates have been formed, not to pretend to apply electric traction, but to tackle the problem and successfully solve it. The men who have taken up the work hold so commanding a position and have made tramway work so much a speciality, that they cannot permit themselves even to think of failure. Their reputation demands success, and they have sufficient knowledge to know that they are not attempting the unattainable. One of these syndicates has been examining into the Short series system as described in our columns a few weeks since, and it is because the syndicate has been advised by the most eminent legal authorities that Short's patent controls the use of motors used in series for tramway work that we call attention to the position. The question is not so much whether the series system is all that its supporters imagine as whether a patent of the kind should be accepted. Other engineers may hold that it is invalid, but to

prove it so will require a costly law suit. Further, if it is permissible to patent series working for transmission of power in tramway work, is it not permissible to patent series working for transmission of power in factories and workshops, when machines, not tramcars, are to be operated? or does the Short patent control this class of work also? Too often the patenting of a well-known device is the outcome of sheer ignorance. Men who know nothing of the subject hear of possibilities in electrical work, commence the study of the subject, do something, or make something not illustrated or described in the text-books before them, and rush to the Patent Office to secure a patent. Once in a thousand times the result may be satisfactory, but usually it leads to trouble and litigation.

PATENTS AND BALANCE SHEETS.

Those who have carefully studied the progress of limited liability and the exploitation of patents know that outside criticisms as to the value of patents are often incorrect. In the preparation of balance sheets much more has to be considered than the time during which a patent has to run. If this were the only consideration, a constant depreciation of between 7 and 8 per cent. calculated upon the original outlay would, upon the expiration of the the patent, wipe out the cost from the balance sheet. It must always be remembered, however, that the value of the business founded upon the working of patents should at any rate for a few years be a progressive one. The real question to be considered is whether or not too great a sum has been paid for the patents; if not, the progressive value of the goodwill of the business should about equalise the depreciation that should be written off against patents. Thus the amount shown upon the balance sheet might well be a constant, and at the expiration of the patents might well be taken to represent the goodwill of the business. The great difficulty to be encountered is from the fact that at the expiration of the patent anybody can enter into the business, and frequently some of the men who have learnt at the expense of the company, and know the *clientèle* of the company, do set up in business for themselves, taking away some of the clients, and competing for new business. Such competition reduces the value of the goodwill, and therefore if the money paid originally for the patents was too great, the due balance above referred to will not be kept. It is difficult to appraise the true value of any patent at the time of patenting, but a fairly simple calculation at the expiration of the patent will show what it should have been if our contention is correct. A similar chain of reasoning holds good in the case of private firms. Here a patent is generally the outcome of experimental work, and the whole cost of that experimental work, as well as the cost of the patent, should be charged against the patent. It would be best and safest in all cases to be able to put the value of goodwill in a balance sheet as *nil;* but it will be seen that in the majority of cases this would be placing too great a strain upon the profits of the first fourteen years, whereas the fact is indisputable that a good paying going concern always has its market value—that is, always commands a price for goodwill. This market value is the exact value which has replaced the estimated value of the patents. Every rule has its exceptions The United Telephone Company, for example, is in the peculiar position of expecting to be troubled at the expiration of its patents by Government interference, hence is in a position wherein the ordinary laws affecting business are inoperative. The result may be to give a fictitious value above or below, as the case may be, the true value of the shares. Under ordinary conditions the true policy in working a patent seems to be to make all possible clients friendly inclined by producing the best materials at the cheapest rate, thus warding off danger from excessive competition, there being no reason why an old and well-satisfied customer should leave the firm he has been dealing with and go to a new one.

MR. VERNON HARCOURT'S NEW PHOTOMETER.

The holophotometer has been designed in order to get rid of two difficulties connected with other methods of attaining the same object—viz., to measure the light emitted in every direction by any luminous source. These difficulties are—(1) The movement of the light to be measured or of the standard lamp, neither of which is desirable. (2) The errors caused in the measurement of lamps provided with reflecting fittings, by the assumption that the flame is the zero point from which measurements should be made, whereas, strictly speaking, the principal focus formed by the reflector should be taken as the zero point. Inasmuch, then, as this focus may be several inches away from the flame, and as the length of bar usually employed is 60in it is evident that serious errors may be introduced by the difference between the real and the assumed zero point. To establish the existence of such an error, and to eliminate it, two things are necessary—viz., that reading should be taken with bars of various lengths, and that the length of the bar should be very great compared with that between the real source of light and the focus formed by the reflector. Both these points are secured by the use of the holophotometer. The instrument is mounted upon a table capable of being moved nearer to or further from a fixed table containing a graduated bar with a movable disc (say, of the Letheny pattern), and having a standard lamp fixed at the zero of the bar. The lamp to be measured is mounted upon, or is in rigid connection with, the movable table, and is, therefore, not moved during a series of readings.

The holophotometer consists of an axis working friction-tight in a collar supported by a vertical pillar. The axis is accurately fixed at the same height and in a line with the centre of the disc. At the end nearest to the disc is placed a large mirror with its centre concentric with the axis, but so arranged that the plane of the mirror may be inclined and clamped at any angle to the axis. At the other end of the axis is fixed a telescopic arm carrying a smaller mirror, which is capable of being turned into any required position, the arm being rigidly fixed to the rotating axis of the instrument, to which is also attached the larger mirror. It follows

that the rotatory motions of the mirrors about the axis are identical. The angles of rotation are measured by the indications upon a divided circle attached to the moving axis, which are shown by a pointer fixed to the upright support.

The mirrors are adjusted in such a way that the light from the lamp to be measured falls upon the smaller mirror, thence is reflected on to the larger one, and finally along the axial line of the photometer disc. As both mirrors rotate together, it follows that if a horizontal beam is reflected correctly, all other beams will find their way along the axis of the photometer. If, therefore, the arm carrying the small mirror be moved through various angles, it will receive the light emitted from the lamp at those angles, and the light will at every angle be transmitted along the axis of the photometer. The divided circle is made large enough to serve as a complete screen of all direct light, and only the light falling on the small mirror can find its way to the disc. In order that absolute as well as comparative tests may be carried out, only one additional measurement need be made. The direct horizontal light is measured without the interposition of the holophotometer (which is mounted so as to be easily moved out of the direct line), then the mirrors are interposed, and a new measurement made. The additional path travelled by the light is allowed for in calculation, and thus the absorption of the mirrors is found, once for all, for the particular character of light under measurement. It is only necessary afterwards to multiply subsequent values by this coefficient of absorption in order to obtain absolute measurements at various angles.

The employment of mirrors in photometry has sometimes led to serious errors; but it will be seen by the foregoing description that, inasmuch as the relative angle of the mirrors is never changed, and as their absorption is easily calculated and allowed for, the only objections to their use have been guarded against and avoided.

In order to eliminate the second source of error mentioned above—viz., that arising from the formation of a principal focus—it is only necessary to take a series of readings with the table in one position, and then move it to a greater distance and take another series. If a focus is formed at a sufficient distance to produce an appreciable error, it will clearly appear in the difference between the readings at the two distances; and then it is only necessary to wheel the table to such a distance that the discrepancy is inappreciable. In other words, this is equivalent to using a bar of sufficient length to make it practically infinite compared with the distance between the focus and the real source of light.

The instrument has been designed specially for use in lighthouse work, where it becomes of the highest importance to measure accurately the total light given by any lamp, and not only that emitted in any one direction, which may or may not be the maximum.

Preliminary experiments made with the instrument by Mr. Stepney Rawson, at the works of the Woodhouse and Rawson Electric Manufacturing Company, have shown what a valuable instrument it is for the determination of the commercial value of various lamps, as well as for assisting in the many difficult problems of the diffusion and reflection of light. The absorption of the two mirrors used is, as already mentioned, stated to be only 1·8 per cent.; but a series of experiments are to be made upon this point.

A PRACTICAL METHOD OF CALCULATING AND DESIGNING DYNAMOS AND MOTORS.*

BY FRANCIS B. CROCKER.

It has happened that a large part of my work for the last three or four years has involved the designing and calculating of the proportions and constants of dynamos and motors, and I have naturally collected a number of methods and ideas relating to this subject which may be interesting and useful to others working in the same field. The methods and views which have been selected are those which I have found by experience to be the simplest and most generally applicable, and at the same time more than sufficiently accurate for most practical purposes.

Almost everyone interested in electricity has *seen* the articles by Hopkinson, Kapp, and others, usually entitled the "Predetermination of the Characteristics of Dynamos." These papers are certainly very able and complete as mathematical feats; but I will venture to say that very few ever actually *read* those articles through, and still fewer persons understand them. This is a fact—not because there are not a great many who are perfectly capable of understanding such articles, but because the latter are so long and complicated, and so bristle with Greek letters and the calculus, that they are very uninviting, to say the least, and ninety-nine readers in a hundred turn to more attractive parts of the book or paper.

In comparison with such elaborate mathematical structures my methods seem very thin and transparent. But as most of us have neither the time nor inclination to use the complicated methods, and as articles and books generally treat the subject in that way, I think a little time may be spent profitably upon the simpler methods, even though some of them may be known to you already.

General Principles.—In the first place let us consider briefly how a dynamo generates electric current and how a motor develops mechanical power. There are various ways of looking at the generation of current in dynamos, the ordinary one being the cutting of magnetic lines of force by an electric conductor. This view is very satisfactory in most cases, but I think it is very often too narrowly considered. For instance, take the old-fashioned Siemens I armature. There is no cutting of lines of force in the ordinary sense, the conductors are not really in the magnetic field at all; they first *surround the lines of force, then loose them, then surround them again in the opposite direction*, and so on. I think the best way is to consider the conductors as cutting so many lines of force, which also means enclosing so many lines of force, which alternate or change in intensity so many times per second. In describing the calculations of E.M.F., I will treat this subject further and give the actual values of the different quantities involved.

Development of Power by Motors.—An electric motor develops mechanical power in exactly the opposite manner to the generation of current by a dynamo. In a dynamo, as we have just seen, the conductor is made to revolve in a magnetic field, and the current is produced in that conductor.

In a motor a conductor carrying a current and placed in a magnetic field is caused to revolve by the action of the magnetic field upon the current. In short a dynamo is a perfectly reversible machine, capable of converting mechanical power into electric current, or electric current into mechanical power, just as the use to which it is to be put requires. Identically the same machine can be used for both purposes, and except for the mere question of detail and convenience, there is no necessity whatever for even modifying the design of the machine to apply it to one purpose or the other. A few years ago it was not generally admitted that the best dynamo is the best motor, but now I think this fact is generally recognised. The experiments of Hopkinson and others on the efficiencies of identical dynamos and motors gave substantially the same results for both.

I will now take up and consider separately the parts of dynamos and motors.

The Armature.—The armature is the most important element of the machine, and is by far the most difficult to correctly design and properly construct.

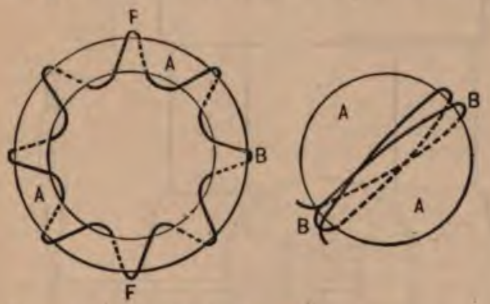
There are two general types of armatures, the "ring" and the "drum." The ordinary Gramme ring is the best and simplest example of the ring armature, and I have always found, in studying or explaining a dynamo or motor, that this form of armature is more easily understood, and the magnetic and electric actions which take place are more apparent. The general principle of the construction of the Gramme ring is illustrated in Fig. 1, in which A is the armature core and B the winding. The advantages of the Gramme ring are: First, the diameter can be increased indefinitely without necessarily increasing the length of each convolution; and, for most purposes, a

* Paper read before the New York Electrical Society.

large diameter of armature is, in my opinion, very desirable. Secondly, the convolutions forming the winding of a Gramme ring do not cross each other, and, consequently, there is less liability to short circuits. The disadvantages of the Gramme ring are: First, the crowding together of the wire on the inside of the ring, owing to the fact that the inside circumference is, of course, less than the outside; and, secondly, the mechanical difficulty of carrying or supporting the wire, due to the fact that the wire is interposed between the iron ring and the shaft.

The ordinary form of drum armature is the Siemens, the general principle of which is shown in Fig. 2, and which is the type most generally adopted by the best makers of dynamos at the present time. For the sake of simplicity only two convolutions of winding are represented. The advantage of the Siemens armature is its solid mechanical construction, the iron armature core being mounted directly upon the shaft. The disadvantages are: First, the small diameter which we are obliged to use in order not to increase the length of the wire across the ends, which is usually considered to be dead or useless wire. Secondly, the piling up of wire on the ends where the convolutions cross each other. There are, of course, various forms of armatures, and some which do not even come under the two classes which I have spoken of, but it would only confuse the subject to attempt to consider all the forms, and if the two most typical and common forms are clearly understood, it is a comparatively easy matter to apply the principles to any other machine.

Electromotive Force.—The E.M.F. which a given armature is capable of developing may be calculated or predetermined without trying it experimentally. It may also, of course, be tested by actual trial in various ways. There are also



Figs. 1 and 2.—Methods of Motor Construction.

several different ways of calculating the E.M.F. These are generally over-complicated and abstruse, and is the most difficult part of the mathematical analysis of dynamos, of which I have already spoken. A very simple method of calculating the E.M.F. in any given case, and one which I have found to give excellent results in a number of cases, is as follows:—

Let us take a typical machine, such as is shown in Fig. 3, for example, in which A is the armature core, B the exterior and B′ the interior portion of the winding, N and S the pole pieces, C C the field magnet, D D the field magnet coils or winding, and E the yoke. Assuming the radial thickness of the ring to be 1in. and its length, parallel with the shaft, to be 3in., then the cross section of one side of the ring will be three square inches. Now, in calculating the E.M.F. we can only take one side of the ring, because the two sides are in multiple arc and do not add their E.M.F. to each other, but merely unite and flow out together at the brushes. I have found by repeated experiments that *each convolution generates from* $\frac{3}{100}$ *to* $\frac{4}{100}$ *of a volt per square inch of armature core, with* 1,000 *reversals per minute.* This is entirely independent of the length of the convolution. The outer convolution generates no more E.M.F. than the inner; the area of the core alone determines the E.M.F. produced. If we double this area we double the E.M.F., other things being equal.

I assume 1,000 reversals per minute as a standard case; it is easy to remember, and it is not very far removed from the number which actually takes place in practice. One thousand reversals is equal to 500 revolutions in a 2-pole machine, because in one revolution the armature core passes once under the north pole and once under the south pole.

I use the term "reversals" instead of "revolutions" because it is general. For example, in a multipolar machine of 4 poles there would be four reversals per revolution. Now, in the machine we are considering there are 3 square inches of armature core on each side, and assuming 1,500 revolutions per minute, or 3,000 reversals, and assuming 300 convolutions of wire *on each half* of the ring, we will have $\frac{3}{100}$ (volt) $\times$ 3 (sq. in.) $\times$ $\frac{3,000}{1,000}$ (reversals) $\times$ 300 (convolutions); or, $\frac{3}{100} \times 3 \times 3 \times 300 = 81$ volts as the E.M.F. produced in this particular case. I assume, of course, that the armature core is saturated, or nearly saturated, magnetically. If it is only half saturated, then the E.M.F. will only be one-half of 81 volts.

In the case of the Siemens armature, the cross-section to be used in this calculation is the full cross-section of the armature core, because each convolution passes entirely round the core. Therefore, if we have a core 5in. in diameter and 8in. long we will have 40 square inches of cross-section; but, as in the case of the Gramme ring, we must use only half the convolutions in the calculation, because the two halves of the winding generate E.M.F.'s in multiple arc with each other and not in series. In a precisely similar manner we may calculate the E.M.F. in any machine by simply *multiplying* $\frac{3}{100}$ *(volt) by the cross section of the armature core in square inches, and by the number of convolutions in series with each other, and by the number of times that 1,000 reversals occur in one minute.*

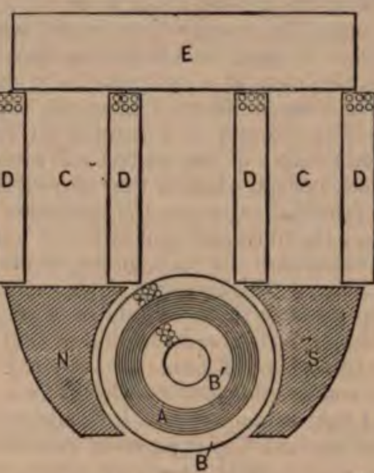


Fig. 3.—Methods of Motor Construction.

Field-Magnets.—In designing the field-magnet of a machine the first question to decide is the material out of which it is to be made. The latest data I have seen give the relative magnetic permeability or magnetic conducting power of different irons as follows:—Cast iron, 10; malleable cast iron, 12; best wrought iron, 18. We see, therefore, that wrought iron is decidedly better than either cast or malleable cast; but in some cases considerations of cheapness or peculiarities of form may make cast iron preferable. Whenever cast iron is used in place of wrought, the cross section of the cast iron should be increased in proportion to its lower magnetic conducting power, *i.e.*, any cast-iron portion or portions of a magnetic circuit should be made at least $1\frac{3}{4}$ times as large as the wrought-iron portions of the same circuit. The second consideration in designing the field magnet is to make the magnetic circuit as short as possible; *i.e.*, the cores should be made no longer than is absolutely necessary to get the required amount of wire on them.

The pole-pieces should generally be made larger than the field cores, particularly if they are of cast iron. By making the pole-pieces larger in cross-section, and covering more of the surface of the armature than the area of the cross-section of the core, we reduce somewhat the magnetic resistance of the circuit, and in most cases there is no objection to this increase in size. I do not believe, however, in covering too much of the armature with the pole-pieces, because if the extremities of the pole-pieces are brought close together there is leakage across between them. Furthermore, the neutral zone, where there are no magnetic lines of force passing into the armature, is reduced, and it becomes just so much more difficult to

set and keep the brushes at the neutral point. Each pole-piece should cover, in ordinary cases, from $\frac{1}{4}$ to $\frac{3}{10}$ of the armature.

The proportion between the cross-section of the field core and that of the armature core as given by Hopkinson, Dugald Jackson, and others, and which agrees with my own experience, is that the latter, to be 75 or 80 per cent. of the former; or in other words, the cross-section of the field core should be one $\frac{1}{4}$ or $\frac{1}{3}$ greater than that of the armature core, assuming them both to be made of the same material. If the field core be made of cast iron and the armature core of wrought iron, then the field should be at least twice the area of the armature core.

The field winding required to obtain magnetic saturation or to fully charge the magnets depends somewhat upon the kind of iron and other conditions, but I have found that it is affected very greatly by the distance between the pole-pieces and the armature core, or what I call the magnetic "jumping space"—that is, where the magnetism passes through the air, which is of very great magnetic resistance. If this space between iron and iron is $\frac{1}{2}$in., it takes about 1,000 ampere-feet per square inch cross-section of field core to saturate it; if the space is $\frac{1}{4}$in., it takes about 700.

You will notice that I speak of ampere-feet instead of ampere-turns, the term ordinarily used. I do this because I have found that ampere-feet apply to any size of magnet, whereas the ampere-turns vary very greatly with different sizes of magnets. It must be obvious to anyone that an ampere-turn in the case of a magnet 1in. in diameter will not produce the same number of magnetic units that an ampere-turn will in the case of a magnet 1ft. in diameter; whereas a given number of ampere-feet will always produce the same magnetic effect, whether they surround a 1in. core or a 1ft. core; provided, of course, the saturation point is not passed. To test the universal application of ampere-feet, I applied it first to the case of a $\frac{1}{8}$ h.p. motor, and then to a 500-light dynamo, both of which worked at the saturation point, and I found that precisely the same number of ampere-feet are required per square inch of cross-section of field core in the one case as in the other. I have also applied it to intermediate cases, and it holds goods with sufficient closeness in all cases that I have come across. I should say, however, that I have not applied it to the case of cast-iron magnets, and, therefore, cannot speak positively about them; but I suppose it would apply to them also, allowance being made for the different magnetic permeability.

Current Capacity.—The amount of current which a given size wire is capable of carrying is, I think, one of the most important questions involved in the designing and calculating of electrical machines. It is not, however, by any means a difficult mathematical problem to solve. The simple rule is that a good copper conductor should have a cross-section of from 600 to 1,000 circular mils. per ampere of current carried. The circular mils are simply the square of the diameter of the conductor in thousandths of an inch The carrying capacity depends, of course, upon the conditions in each particular case. If the conductor is so situated that it may readily lose the heat produced in it by the current, its carrying capacity is increased. A single wire exposed to the air will carry, without overheating, much more current than a mass of conductors lying close together. This applies to thickness of winding. A field-magnet coil, for example, should preferably be not more than one or two inches thick. If thicker than this, the heat is apt to accumulate very objectionably. Other things being equal, a small wire will carry relatively more current than a large one, because its radiating surface, as compared with its mass, is greater than in the case of a thick wire. If conductors are always made at least 800 to 1,000 circ. mils. per ampere, they will be right in ninety-nine cases out of a hundred. The error should be made on the safe side.

Power.—The power of a motor or output of a dynamo may be determined by calculating the E.M.F. and current capacity separately by means of the rules explained above, and multiplying the two together. The product will be the power in watts. The h.p. is found by dividing the number of watts by 746.

A static method of testing the power of a dynamo or motor is represented in Fig. 4. It consists in clamping an arm upon the shaft of the machine so that it cannot turn, and then weighing the pull which the armature exerts with a given current. The power in foot pounds per minute is equal to the pull in pounds muliplied by 6·28 times the length of the arm in feet, and that product multiplied by the number of revolutions per minute at which the machine is intended to run.

This static method is, of course, not as perfect as the regular Prony brake test with the armature running. In the brake test the clamp (in Fig. 4) is loosened so as to give just sufficient friction to allow the machine to run at the prop.r speed, the power being calculated precisely as in the static test. The running test is, however, very much more difficult to carry out, because the friction has to be adjusted to exactly the right point, and it is very much more difficult to weigh the pull exerted by the armature when running at a high speed. An approximate test is infinitely better than no test at all, and there are a great many cases where one would go without making any test rather than try a running one; whereas the static way is so simple and short, and requires so little adjustment that one is not so likely to shirk it.

As a matter of fact, the static method is quite accurate for machines of high efficiency, because in a really good machine of, say, 90 per cent. efficiency, all the losses together are not over 10 per cent.; and the Foucault currents and resistance of air, which are the only losses which cannot be tested statically, are only a portion of this 10 per cent., say, half of it, and, therefore, do not affect the result very greatly. In fact, by allowing five or six per cent. for these two items the results will be almost perfectly

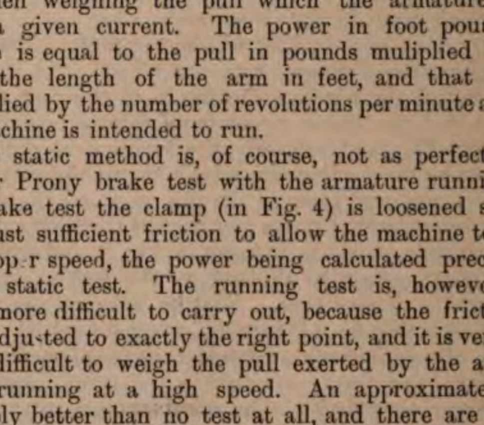


FIG. 4.—Methods of Motor Construction.

accurate in most cases. I am, of course, here only considering the testing of a machine at or near its full power; if it be tested statically at low powers, the errors will be increased proportionally. But certainly the results at full power are really those which it is most important to know. Any machine which is so inefficient that this method does not apply to it, is so poor that it ought not to be built at all. The time for inefficient and improperly designed and constructed machines has gone by.

This same static method of testing power which I have just described enables us also to determine the counter E.M.F. of a motor or the direct E.M.F. of a dynamo running at a given speed. The same arrangement, shown in Fig. 4, is used, and the pull exerted by the armature with a given current passing through it is weighed as before. We have—$E.M.F. \times current \times 44\frac{1}{4} = 6{\cdot}28 \times rad. \times Pull \times Rev.$

$E.M.F.$ is expressed in volts; *current*, in amperes.

1 watt $= 44\frac{1}{4}$ft. pounds per minute.

$6{\cdot}28 =$ circumference of circle when radius $= 1$.

$Rad. =$ radius in feet; $Pull =$ pull in pounds

$Rev. =$ revolutions per minute.

Assuming E.M.F. $= 1$ volt, and $rad. = 1$ft., the equation becomes—

$$Rev. = \frac{7{\cdot}04 \times amperes}{Pull.}$$

That is, the revolutions per minute required to give 1 volt are equal to seven times the amperes in the armature divided by the pull in pounds at 1ft. from the centre.

Let us now apply the foregoing methods to an actual example.

Example: Let it be required to design a series wound motor to give 1 h.p. at 1,500 revolutions per minute on a 10 ampere constant current circuit.

In the first place, it is necessary to choose a certain form of machine. The ring armature is well suited to small motors, because it is not, relatively, so small in diameter; therefore we will select that one as our type.

The best way to begin the calculation is to assume a certain diameter of armature which we think to be about right.

If it is found to be too large or too small we can change it, and the time spent in figuring upon the incorrect size will not be lost, for it will help us in calculating the right size. I have always found it well to work on both sides to the correct size in order to be surer of not making a mistake, and to see the effect of changing the different dimensions.

Armature.—Assuming a ring armature 6in. in diameter when completed, and allowing $\frac{1}{2}$in. on each side for winding, the iron core will be 5in. in diameter. Since the winding is $\frac{1}{2}$in. thickness on the outside of the ring, it will be about twice as thick on the inside, owing to the smaller circumference; and allowing $1\frac{1}{2}$in. for the shaft, &c., we find that the inside diameter of the iron core must be made $1 + 1 + 1\frac{1}{2} = 3\frac{1}{2}$in. Therefore, the radial thickness of the iron ring *A* (Fig. 3) will be $\frac{3}{4}$in. (on each side), since $3\frac{1}{2} + \frac{3}{4} + \frac{3}{4} = 5$. Assuming that the iron core is $2\frac{1}{2}$in. long, the cross-section of each side of the ring will be $2\frac{1}{2} \times \frac{3}{4} = 1\frac{7}{8}$ square inches. The iron ring being 5in. in diameter, the half circumference will be very nearly 8in.

Since the motor is to run on a 10-ampere circuit, each half of the armature winding will have to carry 5 amperes, since in the Gramme armature the current divides into two parts. It has been stated above that 800 circ. mils. per ampere is a good figure; therefore, the size of the wire should be $5 \times 800 = 4,000$ circ. mils. Referring to a table of wire gauges, we find No. 14 B. and S. = 4,106 circ. mils., which we take. No. 14 wire is ·064 in diameter naked, and allowing ·012 for insulation (average allowance), we have ·076 as total diameter. Therefore No. 14 will lay 13 to the inch ($13 \times ·076 = ·988$).

Again, since the half circumference equals 8in., one layer will require $8 \times 13 = 104$ convolutions, and as we have $\frac{1}{2}$in. space for winding we can have 5 layers = 520 convolutions, and still space enough for clearance. Each convolution is about 7in. long $(2\frac{1}{2} + 1 + 2\frac{1}{2} + 1)$, making 300ft. of wire, weighing, according to wire table, 5 pounds, on *each half* of armature, or 10 pounds of wire in all.

We have seen above that the volts produced by a machine = $·035 \times \text{cross-section} \times \text{convolutions} \times \frac{\text{No. of reversals}}{1,000}$. Substituting the values we have in this particular case, $·035 \times 1\frac{7}{8} \times 520 \times \frac{3,000}{1,000} = 102·3$ volts. That is to say, the counter E.M.F. developed by this motor running at 1,500 revolutions per minute will be 102·3 volts. I use ·035 in this case because it is an average value; but, probably, ·03, which I used before, is a surer and safer figure.

Field-Magnet Cores.—The cross-section of each side of the armature core we have determined to be $1\frac{7}{8}$ square inches, and both sides added would be $3\frac{3}{4}$ square inches. Therefore the field-magnet will have to be sufficiently large to fully saturate this area; or, as has already been stated, about 25 per cent. greater, which would make it $4\frac{3}{4}$ square inches very nearly. The diameter of core corresponding to this cross section is $2\frac{1}{2}$in. This is the proper diameter for a wrought-iron core; for cast iron it should be about 70 per cent. greater cross-section, or $3\frac{1}{4}$in. in diameter. The yoke should be made at least equally large.

Field-Magnet Winding.—Since the field winding carries the whole current of 10 amperes, it should be of about $10 \times 800 = 8,000$ circ. mils. = No. 11 wire In the case of the field winding a size larger, No. 10 is safer and better. The length of wire required to obtain saturation with a distance of $\frac{1}{8}$in., between the pole piece and armature core is 1,000 ampere-feet per square inch area. In this case the field core is $4\frac{3}{4}$ square inches in section. Therefore, we shall need 4,750, say 5,000 ampere-feet; and since the current is 10 amperes, the necessary length of wire is 500 feet, including *both* cores, weighing about 20 pounds insulated. The cores are $2\frac{1}{2}$in. in diameter, or about 8in. in circumference; therefore, there will be $\frac{12 \times 500}{8} = 750$ convolutions, or 375 on each core. (The number 12 in the equation stands for the number of inches in a foot.) Each convolution occupies $\frac{1}{8}$in., and, assuming the cores to be 7in. long, each layer will have 56 turns, and there will be seven layers.

The resistance of 500ft. of No. 10 wire, according to wire table, is $\frac{1}{2}$ ohm; and therefore the fall of potential in the field winding with 10 amperes will be 5 volts, according to Ohm's law.

We have calculated that the armature will have two circuits, each consisting of 300ft. of No. 14 wire. The resistance of one of these is ·8 ohm, and of two in multiple arc, as is the case here, is ·4 ohm; consequently, the fall of potential due to the resistance of the armature is 4 volts.

The counter E.M.F. has already been found to be 102·3 volts; adding to this the drop of 5 volts in field and 4 volts in armature, we have 111·3 volts as the total E.M.F. required to be supplied to the motor, which, multiplied by 10 (amperes) gives 1,113 watts as the total electrical power absorbed by it.

The net commercial efficiency of such a motor should be 75 per cent., hence the actual mechanical power developed will be equivalent to $·75 \times 1,113 = 834$ watts; and allowing 10 per cent. more as a margin we have 750 watts, or 1 h.p., almost exactly, as the true working power of this motor.

In the same way and using exactly the same data and principles, any other motor or dynamo may be designed, and its proportions and constants predetermined.

I have assumed throughout the above that the materials and construction are good. The wrought iron, copper wire, &c., should of course be of good quality. The armature core should be made up of laminæ of soft sheet iron, separated by tissue paper or other insulator, and the shaft, bearings, and other mechanical parts should be large enough and properly made. Otherwise the machine will not come out as it should.

WEYMERSCH BATTERY TESTS.

We have received the following report of Messrs. H. Alabaster, Gatehouse and Co., made to Mr. McKenzie, relating to a new primary battery, which is interesting in that the result shows a nearer result to the theoretical consumption of zinc than has hitherto been the case in primary batteries.

"In compliance with the request which you made to us towards the end of last month, that we should conduct a series of tests with, and report upon, a new depolarising liquid discovered by M. Weymersch, and employed in batteries of the Bunsen type, we beg to submit to you the results of our investigations.

"A preliminary trial was made with three square open jars, each having the following internal dimensions—$8\frac{1}{4}$in. by $8\frac{1}{4}$in. by 12in. deep. The quantity of sulphuric acid and water, in the proportion of 1 to 20, in each jar, was about 16 pints. Immersed in this solution were two $6\frac{3}{8}$in. wide zinc plates, to the depth of $6\frac{1}{2}$in. Between the zinc plates, and placed in a porous pot, $7\frac{1}{4}$in. by $1\frac{1}{2}$in. by 12in. deep, containing nearly $3\frac{3}{4}$ pints of the depolarising fluid, was the carbon electrode, of the same linear dimensions as the zincs. These cells were connected in series to an ampere-meter, the current being adjusted by iron-wire resistances to 10 amperes, or thereabouts, and kept in circuit for 26 hours. The results obtained showed that the battery ran for 26 hours without the current ever falling below 10 amperes, or varying more than 5 per cent., and with a drop of less than 5 per cent. between the maximum and minimum free potential of the cells, whilst an actual rise in the working or available E.M.F. took place. The measured consumption of zinc in the battery, moreover, was only about 8 per cent. above that indicated by theory.

"We then decided to employ another battery of five cells, precisely similar in all respects to the above, and in the

TABLE.

Date	Time.	Duration (t).	Current (c) amps.	E.M.F. Volts. Open.	E.M.F. Volts. Closed.	Resistance per cell. Ohms.	C E t (external circuit). Watt hours.	Theoretical weight of zinc dissolved. Grammes per cell.	Actual weight of zinc dissolved. Grammes per cell.	Difference between theoretical and actual consumption. Per cent.	Remarks.
June 7th...	11:0 a.m.	...	10·1	9·26	5·70	·070	...	...	...	...	
	12:0 ,,	1	10 4	...	5·75	...	58·97	12·436	...	...	
	1:0 p.m.	1	10·4	9·26	5·90	·065	60·58	12·618	...	...	From 7:30 p.m. on June 7 to 11 a.m. on the 8 h the battery was left to itself 15¼ hours.
	2:0 ,,	1	10·4	...	6·04	...	62·09	12·618	...	...	
	3:0 ,,	1	10 5	9·26	6·04	·061	63·12	12·679	...	...	
	4:0 ,,	1	10·5	...	6·08	...	63·63	12 740	...	...	
	5:0 ,,	1	10·6	...	6·08	...	64·14	12·800	...	...	
	6:0 ,,	1	10·6	9·26	6·08	·060	64·45	12·861	...	...	
	7:0 ,,	1	10·6	...	6·08	...	64·45	12·861	...	...	
	7:30 ,,	½	10·6	9·08	6·08	·057	32·22	6·430	..	...	Current density 0·12 amperes per square inch.
June 8th...	11:0 a.m.	15¼	10·5	9·06	5·89	·060	978·70	198·400	...	...	
	12:0 ,,	1	10·4	...	5 85	...	61·34	12·679	...	...	
	1:0 ,,	1	10·3	9·06	5·85	·062	60·55	12·558	...	...	
	2:0 ,,	1	10·3	...	5·85	...	59·65	12·497	..	...	
	3:0 ,,	1	10·2	8·95	5·75	·063	59·45	12·436	...	...	
	4:0 ,,	1	10·2	...	5·70	...	58·40	12·376	..	...	
	5:0 ,,	1	10·1	8·95	5·70	·064	57·86	12·315	...	...	
	6:30 ,,	1½	10·0	8·95	5·65	·066	85 54	18·290	...	...	
...	...	31½ hrs.	...	...	...	...	1955·14 per cell = 391	399·594	439·7	10 0	...

table appended hereto all the necessary data is furnished. After keeping the cells on closed circuit for 31½ hours, we were compelled, owing to our desire not to leave the battery alone through another night, to put an end to the experiment, although we have not the least doubt that several hours more work could readily have been obtained before the electrical constants were reduced to the extent of rendering it undesirable to continue the readings. During this lengthened run it will be seen that the free potential of the battery did not vary more than approximately 3 per cent., that the working electromotive force was practically the same at the end of the test as in the beginning, and that the current varied only between 10 and 10·6 amperes. The actual and theoretical consumption of zinc differ by only 10 per cent., which agrees closely with the data obtained in the preliminary trial, the weighing of the electrodes in the last run having been carried to a greater degree of precision and exactitude, necessitating the employment of grains in balancing plates of zinc, each weighing nearly 3lb.

"The electrical measuring instruments which had very kindly been loaned to us by Messrs. Sharp and Kent, were independently checked by Mr. H. R. Kempe and Mr. W. M. Mordey. The price per h.p. hour agrees more closely with the theoretical cost of batteries in which zinc is consumed than that of any other with which we are acquainted, although, of course, the precise figure will largely depend upon the charge per gallon the inventor chooses to make for the depolariser, which, we are informed, can be manufactured at sixpence per gallon.

"We have not hitherto had any battery submitted to us which has given results approaching those above tabulated, and we have no hesitation in expressing the opinion that M. Weymersch has effected a great advance in two liquid primary batteries. We may add that the liquids did not appear to rise in temperature during the whole period of the test, a fact which we imagine is unprecedented in batteries of the Bunsen type.

"It has long been the aim of inventors to discover a primary battery which should give a high electromotive force, possess a low internal resistance, and give a large and constant current for a considerable period of time with the minimum amount of attention and at the lowest possible cost. In our opinion, M. Weymersch has distanced all competitors in the attempts hitherto made to fulfil the above conditions."

Gas or Electricity.—The policeman settled the question the other day, when a leaky gas pipe exploded and blew up the footpath. Some said it was sewer gas, and some thought it was the electricity which had got buried from the late storm; but the bobby said he knew all about, "It's nothin'. Only the telegraph's busted!"

PROTECTION OF BUILDINGS FROM LIGHTNING.*

BY PROF. OLIVER J. LODGE, D.SC., F.R.S.

Lecture I.

One hundred and fifty years ago the nature of lightning was unknown. Several persons surmised that it had some connection with the phenomena excited in a piece of glass tube when rubbing it, phenomena which were called electric; but no proof of the connection was attempted. The proof that lightning was in fact nothing but a large electric spark was given, as you know, in 1751, by that marvellously comprehensive and common sense genius, the Philadelphian printer, Benjamin Franklin.

This great man, a statesman of the first magnitude, might have made one of the first experimental philosophers, had he lived in quieter times instead of having to take a prominent part in the Declaration of Independence and in the great American War. A space of some twelve years limits his active devotion to electrical matters, but in that time he acquired a masterly grip of the subject, expressing himself very accurately and precisely concerning electrical theory, his statement of which is far superior to a great deal that has quite lately passed current in text-books; indeed, it is only now becoming capable of improvement through the labour and the inspiration of some of the still greater giants of our own day.

From the time that Franklin flew his kite at Philadelphia and ascertained beyond cavil the true nature of lightning—from that time to the present the protection of buildings and ships from its destructive agency has been mainly a matter of detail and application of the laws of electricity so far as they were known.

For a long time the erection of lightning-conductors was opposed by the religious world as heretical and impious. But, first in some Protestant provinces in Germany, and later in France and England, the use of the heretical rods gradually extended. The extension of their use in England and their application to ships were greatly aided by the labours of that enthusiastic worker, Sir W. Snow Harris. Their extension in our South African colonies, where violent thunderstorms are frequent, is largely due to the influence of the late Dr. Mann, in whose honour this course of lectures has been established Anyone who has read or heard Dr. Mann's contributions to the *Journal* of the Society of Arts,† must have been struck not only with his keen interest and enthusiasm, but also with his grasp of fundamental principles, his open-minded, receptive attitude to new controvertible views, and the thoroughly practical and business-like way in which he handled the subject

Concerning the origin of atmospheric electricity, I have not much to say. It seems to me probably due to friction, like Armstrong's hydro-electric machine. Faraday showed that the exciting cause in that apparatus of Armstrong's was the friction of water spray driven by steam over the solid surface of the jet; so, also, I picture winds in the atmosphere driving the spray of mist against rock and ice surfaces, and so gradually producing a certain difference of potential between the upper layers of the atmosphere and the surface of the earth.

I have spoken as if I thought the friction had to be

* Dr. Mann Lectures, delivered March 10, before the Society of Arts.
† *Journal* of the Society of Arts, April 30, 1875, and March 15, 1878.

between mist globules and solid matter. It seems doubtful whether friction against *air* will suffice to render water electric. If it is efficient, then it is well to notice that, though there is no finite slip between bodies and the common air through which they move, yet this does not apply to rarefied air. The viscosity of rare air is as great as that of dense, but the slip of solids through it is another matter. In rare air there is an actual slip at the surface, and accordingly the *apparent* viscosity of rare air, as observed by the settling of dust or the falling of a feather in a vacuum, is less than in air at common pressure. It may be, therefore, that the finite slip of mist or dust-particle through the upper layers of the atmosphere is one effective cause of atmospheric electrification; and after a spell of dry weather there is liable to be an accumulation of electricity, because it has had no recent opportunity of escape.

In the polar regions electrical discharges are mainly silent, or brush-like, giving the fantastic forms of aurora; but in our latitude these silent discharges in the upper semi-conducting rarefied layers of atmosphere are seldom visible. We see the effect in another form. The electrification gets occasionally conducted down by clouds into the lower and denser layers of atmosphere. By the aggregation of small globules into great ones the potential is enormously raised, until in the lower atmosphere they flash either into each other or into the earth, and the strain is partially relieved.

It is important to note that clouds appear to play only a secondary part in the phenomena. The upper regions of atmosphere are at a different potential from the earth—cloud or no cloud. Clouds are able to conduct it down towards the earth, and thick, dense clouds are therefore the usual prelude to a thunderstorm.

The way in which coalescence of small charged globules into larger globules is competent to raise their potential enormously is well understood, and I need not dwell upon it;* but the converse operation, or the tendency to coalesence of globules produced by feeble electrical charges in their neighbourhood is not so well known, and I proceed to show the very simple experiment described by Lord Rayleigh, with a water jet and sealing-wax.

A vertical jet, about one-twentieth of an inch in diameter and three or four feet high does best, but almost any fairly vertical jet of clean water will serve. The drops fall as a scattered shower, like fine rain, until a stick of excited sealing-wax is held a yard or two away; they then instantly collect into large globules and fall as a thunder shower.

We have now to think of ourselves as living always between the coatings of a large condenser or Leyden jar, the upper coating the sky, the under coating the earth, the common air is the dielectric between. Ordinarily the sparking distance is far too great. Every now and then portions of the upper coating protrude down as clouds, and we are then liable to a disruptive discharge. Some square miles of cloud and some square miles of land are the two coatings, and the interval of separation need not be extremely great. If the cloud and the earth were perfect conductors, all this great area would be relieved in a single flash of awful size; but, fortunately, the conduction of cloud is a slow process, and it usually takes a good many flashes from different parts to remove its charge.

The total maximum energy of a given area of cloud at a given height from the earth is easily estimated, for it is well known that as soon as the electric tension of air reaches the limit of about half a gramme weight per square centimetre, disruption occurs. Supposing it all equally on the verge of giving way, the energy of the dielectric per cubic centimetre is therefore $\frac{981}{2}$ ergs, and per cubic mile is $\frac{4,110 \times 10^{12}}{2 \times 3 \times 10^{7}}$ foot-tons $= 70,000,000$ foot-tons.

Given, then, the whole area of cloud facing the earth, and its height when on the point of discharging at every point, and you have the number of cubic miles of strained dielectric, and an approximation to the energy of the storm, at the rate of 70,000,000 foot-tons per cubic mile.

The potential needed to give a spark a mile long is so enormous† that the quantity of electricity required to give this energy need not be very great; $2,176 \times 10^{8}$ electrostatic units of quantity per square mile would give a bursting tension. Now, $2{\cdot}176 \times 10^{11}$ electrostatic units is just about 70 coulombs, or not enough to decompose one-hundredth of a gramme (1-7th of a grain) of water. Faraday stated this, but it is often disbeleived.

As to the cause of the curious V-shaped troughs or depressions and horizontal whirls that are often found associated with thunderstorms, I have no suggestion to offer, but on those heads I may refer to Mr. Abercromby's recent little book on the "Weather" (Int. Sci. Series, 1887).

Thinking now of a cloud and of the earth under it as forming the two coats of a Leyden jar, in the dielectrics of which houses and people exist, we have now to consider what determines a discharge, and what happens when the discharge occurs. The maximum tension which air can stand is half a gramme weight per square centimetre. At whatever point the electric tension rises to this value smash goes the air. The breakage need not amount to a flash—it must give way along a great length to cause a flash; if the break is only local. nothing more than a brush or fizz need be seen. But when a flash does occur it must be the weakest spot that gives way first—the place of maximum tension—and this is commonly on the smallest knob or surface which rears itself into the space between the dielectrics.

If there be a number of small knobs or points, the glows and brushes become so numerous that the tension is greatly relieved, and the whole of a moderate thunder cloud might be discharged in this way without the least violence. This is by far the best way of protecting anything from lightning; do not let the lightning flash occur if you can possibly avoid it. But one cannot always prevent it, even by a myriad of points. A good deal more might be done in this direction than is done, but still, sometimes a cloud will descend so quickly, or it will have such a tremendous store of energy to get rid of, that no points are sufficiently rapid for the work, and crash it all comes at once. One specially noteworthy case when points are no protection occurs when one cloud sparks into another, and thence to the ground; or, in general, whenever electric strain is thrown quite suddenly upon a layer of air. (*See* Lecture II. for details.)

When a flash occurs, a considerable area is relieved of strain, and the rush of electricity along the cloud and along the ground toward the line of flash sets up a state of things very encouraging to another or secondary flash or flashes practically simultaneous with the first.

One consequence of this is known as the back stroke or return stroke. It was studied by Lord Mahon, and depicted in his work, "Principles of Electricity," published in 1780. Prof. Tyndall has made it extremely well known, so that a reference to it is made in almost every elementary science school in the country.

But the popular account of the matter is, I believe, very inadequate. It says the man's electrical condition is disturbed by the inductive action of the cloud, and that, on the cloud being discharged, the man's original condition is restored; the passage of the induced charge from his hat to the ground being enough to kill him.

Now the shock that a man could get that way is but feeble; it is only twice what he would get if completely isolated and exposed to inductive action. The amount of charge stored up in a man's hat is not great; the electric tension is more likely to pull his hat off than its release is likely to do him any damage.

I do not deny the existence of this static return shock, but I assert it to be impotently feeble. One can feel all there is to feel by holding a hat near an electric machine till nearly bursting tension, and then discharging the machine. There is no special object in waiting for a thunderstorm.

There is more in the term "return stroke" than a mere recovery from statical disturbance of equilibrium. It is a matter to which I must return at some length next week.

Now proceed to the kind of damage done when a building is struck, and to the customary and orthodox modes of protecting them from the effects of a flash when it does occur, as well as if possible, of warding off the flash altogether by silent discharge. The two main destructive aspects of a lightning flash are (1) its disruptive, or expanding or exploding violence; (2) its heat.

The heating effect is more to be dreaded when the flash is slow and much resisted; the bursting effect when conducted well except at a few places. A noteworthy though obvious thing is that the energy of the discharge must be got rid of somehow. The question is, how best to distribute it. It is no use trying to hocus-pocus the energy out of existence by saying you will conduct the charge to earth quite easily and quietly.

The disruptive effect is well shown by the effect of lightning on trees. It is as if every cell were burst by the expansion in the path of the discharge. The effect on conductors is, however, just as marked. Here are five specimens of wires deflagrated on glass by a Leyden jar discharge—gold, silver, copper, iron, and platinum; each has its characteristic trace, by which it can easily be recognised.

[A number of pictures of damage done to buildings and ships by lightning were here thrown upon the screen. They are mostly contained either in Mr. Anderson's work on Lightning Conductors or in Mr. Tomlinson's on the Thunderstorm, or in both.]

St. George's, Leicester, is a curious case, for the rod of the vane conducted the flash half-way down the spire, when it blew a ring of stones out, and so dropped the top half of the spire neatly inside the bottom half, making a tremendous smash, carrying away all the floors of the tower, and beating in the foundation-arch.

Ships may have a mast utterly destroyed and split to pieces—thick iron hoops binding the mast being rent asunder and flung about by the force of the expansion; or the heat of the flash may ignite the sails, or other combustible matter.

* See a lecture on "Thunderstorms," by Prof. Tait, in *Nature*, August, 1880.

† The difference of potential for a spark a mile long, between flat plates, is roughly 16×10^{7} electrostatic units.

Now take a few examples of buildings or ships more or less protected by conductors. Some of these examples are very instructive as calling attention to the vagaries and unexpected behaviour of powerful flashes. It is these vagaries which I consider have been hither unexplained, and it is precisely these to which I wish to direct your special attention.

I shall hope to show next week how closely and completely they can be illustrated by laboratory experiments, and I believe that it is to a neglect and misunderstanding of these phenomena that so many of the partial failures of conductors have been due.

For that conductors often fail is undeniable. It is customary to say they are not properly made, or that there was a faulty joint, or that there was a bad earth. A bad earth is the favourite excuse. A good earth is a good thing undoubtedly, and one cannot well have too much of it; but for a flash to leave a fine thick copper conductor on a tall chimney while still high up, and begin knocking holes in the brickwork in order to make use of the soot, or the smoke, or some bolts, or other miserable conductors of that sort, because it is not satisfied with the moderate allowance of earth provided for it at the bottom, is evidence either of simple perverseness, or else of something more deep-seated not yet properly called attention to.

If the earth is bad, the flash can show its displeasure when it gets there by tossing it about, and boring holes into it, and breaking water and gas mains; but at least it might leave the top and middle of the chimney alone—it might wait till it got to the badly-conducting place before doing the damage. Yet it is notorious that on high chimneys a flash often refuses to follow a thoroughly good conductor more than a quarter or half way down, but takes every opportunity of jumping out of it and doing damage.* Why is this? Well, that is the main question I shall attempt to answer in this course.

It may be said that the effect of the bad earth is to make the whole path so highly resisting that the discharge necessarily declines to take it. Well, if that were so, it need not have come into the conductor at all. It is supposed with one breath to strike the conductor because it affords an easy path to earth, and with the next it is said to leave the conductor, because after all it finds it a bad one.

Besides, it need not be so very particular about a little resistance; it has already come through, say, half a-mile of clear air—it might manage a few feet of dry soil. It strikes violently through the air, enters the conductor, and begins to go quietly. Why does it not continue to go quietly till it gets to the bottom of the good conductor, and *then* begin displaying its vigour by boring holes below, as it has done above? Why should one end have to be so persistently cockered up? Why not insist upon having not only a good "earth," but also a good "sky"?

Let me repeat, a good earth is a good thing, and it is not possible to have too much of it, except on the score of expense, but even if it were so good an earth that it might be almost called a heaven, it would not stop the tendency to side flash. One would still be liable to spittings out from conductors, especially from tall stout ones, as I shall hope to clearly show next time. However bad an earth may be, it can hardly be worse than one afforded by soot, and bricks, and yards of air.

My position at present is that an earth is desirable to prevent damage to pipes, foundations, and other things buried therein. But that, *so far as getting rid of the flash is concerned*, it ought to suffice if the conductor was cut off level with, or even a foot or two above, the ground. It would knock things about in jumping the rest of the way, but it should not be expected to leave the conductor until it gets to the break, any more than it should be expected to take the conductor half way down instead of at the top. It is true it sometimes *does* partially take the conductor at the middle, just as it sometimes partially leaves it at the middle, but I say that it is not to be expected to do either of these things on ordinarily accepted principles. There are some differences between the behaviour of positive and negative electricity, but none of such extent as will explain the extraordinary difference between the two or three points pointing skywards, and the extensive roots advocated at the other end.

Take these examples now. A house where the lightning, having struck the conductor, flashes off from it in two places to get to a roof gutter and a distant water-butt. Here is a ship where the lightning is striking in two places at once, the top of the mast and the yardarm. In the next it is striking at the top of the conductor, and also at a point on deck, and at two places on land as well. This is a most instructive example. I have little doubt that the three are echoes or reverberations of the main flash, and excited by it; not excited by induction, as in a coil, still less by mere static return, but by a surging or momentum of electricity, of which I have more to say. The next diagram shows the ship "Conway," capitally protected, except as to its flagstaff. The water was seen to be luminous in conducting away this flash from the sides of the ship. Here is the arrangement by Snow Harris of conductors able to accomplish this protection—simple and effective. A ship is an easy thing to protect, provided you realise that every mast and every spar is liable to be struck. If you protect the masts, you may chance the spars if you like; but you are not to think of areas of protection; all such ideas are perfectly illusory.

(Figures of certain houses with elaborate conductors were shown.)

Nothing projecting upwards is left unspiked, and the earths are thorough. These appear to be examples of excellent, though certainly expensive protection.

If these houses were powder magazines, we should have to be more careful still and make a more critical examination, but as ordinary houses they are safe so long as the conductors are in decent condition.

Now, rapidly run over ordinary good orthodox conductors. First, the sky end. Points are good, as explained, but platinum points are liable to be melted. The best points are cones of copper, not too sharp, and thickly gilt. Gold is better than platinum in being just as durable and much better conducting, and therefore less liable to melt. Many points are better than one, especially as some are apt to get fused and blunted by some discharge; others may still remain sharp.

True, anything will act as a point when the tension rises high enough; but the great thing is to keep down these dangerous tensions if any way possible. So soon as a knob begins to emit brushes, the sparking point cannot be far distant; but sharp points will glow and reduce the strain far before the sparking point.

Perhaps the best protected building in the world is the Hôtel de Ville at Brussels, the hobby of M. Melsens. The whole system used in this building is excellent, and theoretically perfect, so far as I know, in every respect; but it is not cheap, and some people might perhaps hold that it was not artistic.

As for the main conductors, one finds rod, rope, and ribbon. The plan most approved, perhaps, by the lightning-rod conference is this copper-tape, which is very nice, neat, and flexible, and free from joints.

Two important matters to be thought of in connection with the conductor are—that it shall not corrode away in places, and shall not be stolen. Another point that must not be overlooked in fixing up any length of conductor is that it is liable to expand and contract. An allowance must be left for this. When it is remembered that it is liable to be exposed to the full glare of the sun, backed up sometimes by a kitchen chimney behind, and then again at another time exposed to the coldest nights, a range of 100deg. C. is not excessive.

I once rigged up some copper rod battery conductors of substantial thickness between two walls, and one morning after a frost found one snapped clean in half by the contraction. This would be a bad thing to happen to a lightning conductor, so either bends must be left in the rope when put up, or else special compensators must be introduced at intervals.

The allowance for copper is one in 500; say an inch in every 40ft. The best place for a compensator is just above a holdfast, so that it will have to support no weight. A bight or bend in a flexible rope answers every purpose, but bends should not be made too sharp, or the discharge will jump across instead of going round. That is a thing to be remembered. Flexible conductors are very convenient, but their convenience must not be abused. Always take them as straight as possible. Lightning has no time to go round circles—it will jump across sooner. Why should it not be let to jump across? Well, because it burns the conductor. That is the real objection to bad joints—the extra heat; a sort of arc produced there, and the liability to fusing and destruction of the conductor at these parts. There is, moreover, some danger from fire.

Now about the earth end. We have had examples of good earths already. Here is a cheap one advocated by Dr. Mann: wire rope opened out into a brush, and the two ends of another short bit, similarly treated, spliced across the first. Two of the fuzzed out ends make contact with deep soil, one with the surface soil, so that one or other is pretty sure to reach moisture.

The whole conductor introduced into the Cape by Dr. Mann is simple, cheap, and admirable for cottage purposes and for emigrants. Squatters in the States, or Canada, or at the Cape are far more liable to thunderstorms than we are in this country and they should certainly rig up one of these homely things. A bit of iron fencing rope will do, with both ends fuzzed out, one supported by a tube fixed to the chimney, the other sunk deep into moist ground, or swamp if available.

In towns where there are water or gas mains anywhere near the terminus of a lightning conductor, they should always be connected to it; and this mainly for their own protection. For if they be not connected, the lightning will not scruple to still make use of them if he chooses, and having to jump across a yard or two of bad conductor on the way, it can easily knock a hole in them or melt them, instead of getting to them quietly.

It must be understood that what I say of the mains and underground does not apply to the pipes in a house. To connect lead water-pipes with a lightning-conductor might possibly lead to their being melted; but to connect the house gas-pipe with

* For an example of the entire failure of a brass rod, 1in. in diameter, see Anderson's book, p. 137. For cases of capricious leaving of a conductor for such things as safes and fowling-pieces, see pp. 250 and 273.

a conductor is a most dangerous proceeding. The neighbourhood of gas-pipes in a house must be scrupulously avoided. The more it is connected to the mains underground the better, but one does not want lightning rushing along compo-pipes, picking out all the bad joints, and lighting all the gas there. In so far as a house contains escaping gas or weak gas-pipes, it must be treated like a powder magazine, and great care be taken. A ridiculously minute spark may ignite gas without being noticed, the hole in the pipe may quietly enlarge, and the house be burnt down. A considerable amount of damage has been done in this way. So soon as Swan lamps are in universal use, lightning may occasionally play havoc with their filaments and fuse a few cut-outs, but it will not find the leads easily combustible or capable of burning the house down.

Whether it be gas or electric light, however, lightning should, if possible, be kept out of the house-leads—not only because of the danger it may do at joints and insulation, but because the gas-brackets and chandeliers are usually conveniently suspended over desks and near arm-chairs, just where an unsuspecting person's head is likely to be; and a spark to one's head is unsafe.

Hitherto I have spoken of the orthodox system of protection, the gather up and carry away system. But, as you know, there is another system suggested by Clerk-Maxwell, the birdcage or meat safe principle. In a banker's strong room you are absolutely safe. Even if it were struck, nothing could get at you. In a birdcage, or in armour, you are moderately safe. I should not care to try armour myself, the joints might get unpleasantly hot and explosive. And even the birdcage, if struck by a big enough flash, might get melted. A melted patch on one's protective armour would be extremely disagreeable. Sometimes one is told to get thoroughly wet through instead of seeking shelter in a thunderstorm; but it is a question whether a stroke is more unpleasant than rheumatic fever.

However, a sufficiently stout and closely-meshed cage or netting all over a house will undoubtedly make all inside perfectly safe. Only, if that is all the defence, you must not step outside, or touch the netting while outside, for fear of a shock. It would be unpleasant, when you reached home out of a storm, to find it so highly charged as to knock you down directly you tried to go in. An earth connection is necessary as well.

A wire netting all over the house; a good earth connection to it at several points, and a plentiful supply of that barbed wire which serves so abominably well for fences, stuck all over the roof, and you have an admirable system of defence.

Now let us see how far most people agree, and where they begin to branch out and differ. The old and amusing political controversy between knobs and points has disappeared. Points to the sky are recognised as correct; only I wish to advocate more of them, any number of them, rows of them, like barbed wire—not necessarily at all prominent—along ridges and eaves. For a point has not a very great discharging capacity. It takes several points to discharge readily all the electricity set in motion by a moderately-sized Voss or Wimshurst machine. Hence, if you want to neutralise a thundercloud, three points are not so effective as 3,000.

No need, however, for great spikes and ugly tridents, so painful to the architect. Let the lightning come to you; do not go to meet it. Protect all your ridges and pinnacles, not only the highest, and you will be far safer than if you built yourself a factory chimney to support your conductor upon. At present the immediate neighbourhood of a factory chimney or steeple is not a safeguard, but a source of mild danger. But no one need believe this till after next Saturday, and not then if the experiments fail.

Next, as to the conductor. Should it be iron or should it be copper? Should it be insulated from the building, or should it be connected with all the metal it contains? These are questions at present in dispute. The lightning-rod conference approves copper, though not putting it specially and strongly before iron. Durability is its main recommendation. Under all circumstances I am not sure whether it is more durable than galvanised iron. Mr. Preece has great experience of wires in chemical and all other districts, and I believe he upholds iron. Franklin and the Americans to this day prefer iron. Certainly it is much cheaper, and not so easy to melt. We will consider the question, and, I think, come to a definite conclusion next week.

Also the question about connecting up the conductors to all metal masses, roofs, girders, balconies, water gutters, &c., we had better leave that open too. Nearly everyone condemns insulators, but one eminent authority, M. Callaud, advocates caution and circumspection in what things you connect and what you do not connect. He points out, for instance, that if you connect up a balcony to a conductor, a person standing thereon may become one of its striking terminals. I must say I agree with him. Some there are who advocate connecting *both* ends of a roof gutter, or other such nearly closed contour, and not only one end. I decidedly agree with this also, for reasons which next week will make abundantly clear. On this point I have, in fact, no doubt.

As regards the shape of the conductor, whether rod or ribbon? Many experiments have been made, notably some by Mr. Preece on the discharge of Dr. De la Rue's battery through conductors of various sectional shapes, to see if extent of periphery matters. Hitherto the results have been negative. We may conclude, I think, that it does not matter much as regards liability to be deflagrated. But theory clearly points to the fact that a bundle of detached wires is electrically better than a solid rod of the same weight per foot, in every respect except durability. But durability is an essential feature. No shape can be considered satisfactory which aids corrosion. One thing is obvious—plenty of surface encourages cooling, and slightly diminishes danger of melting. Its other much more important advantages we will consider later.

Lastly, the "earth" and its testing. An earth is necessary, or you will have your foundations knocked about and your garden ploughed up. A good earth is desirable. A few tons of coke with the conductor coiled up amongst it is a well-known and satisfactory plan if the soil be permanently damp. A bag of salt might perhaps be buried with it to keep it damp throughout, or rain water may be led there. Often, however, the most violent thunderstorms occur after a spell of fine weather, and the soft is likely to be dry. It is best, therefore, to run your conductor pretty deep, and there make earth.

It is all very well to connect the conductors to water mains if near, but if they are far off or non-existent it is no use, and in no case, in my opinion, should they be used as sole earths. Certainly not gas mains. In dry weather they are not earthed at all well, and a strong charge may then surge up and down them and light somebody else's gas in the most surprising way. It does not often happen, but it may happen in sandy soil after dry weather. Always there should be a good deep earth—a well if possible, a boring if not—and the conductor be led down into it. If it likes to make a disturbance when it has to leave the conductor a long way down, no one need grumble. It can't do much harm there. There is, of course, no magic in water, unless it forms a large continuous sheet. An isolated puddle in a rock, such as has been used before now for a lighthouse, is no earth at all. A thoroughly good earth is really a geological question; and for an important building a geological specialist should be consulted.

An occasional test of an earth, in ordinary weather, is no real security as to what may happen after a long-continued drought. It would be easy to arrange a plan whereby just raising a handle shall give sufficient information as to the state of the earth, without any skilled operator. To this end, two earths should be provided, quite independent of each other (one a water-main, for instance; the other a ton of coke), and they should be connected, first to each other and then to the conductor, by a substantial copper band. Now let the band connecting the two earths pass through some covered outhouse, and have a well overlapping junction of two flat areas pressed together by a spring, but capable of being raised on or off the other by pulling at a handle or a rope. A galvanometer indicator and Leclanché cell, permanently connected so as to send a current between the two earths directly the handle is raised, will show by its deflection the state of conductivity of the two earths. Very likely the two earths themselves will suffice to give the necessary current without an auxiliary battery.

There is this to be said, however. If a building is so situated, either on high sandy ground, or on impervious rock, that a decent earth is very difficult to get, then, at least, the house is not likely to make a better earth than the conductor. That is a weak point in the excuse so often made concerning an accident to a protected building, that the earth was not sufficiently good. It can very seldom be shown that the earth, apparently chosen in preference, was any better. Often it was obviously worse.

It is a superstition to place much reliance on the testing of conductors with a galvanometer and Wheatstone bridge. A galvanometer and Wheatstone bridge are powerless to answer many important questions. A Leclanché cell can no more point out what path lightning will take, than a trickle down a hill-side will fix you the path of an avalanche. The one is turned aside by every trivial obstacle, and really choose the line of least resistance; the other crashes through all obstacles, and practically makes its own path. A flash strikes a house at one corner, rushes apparently part way down the conductor, then flashes off sideways to a roof-gutter, sends forks down all the spouts, and knocks a lot of bricks out. Another branch bang through a wall in order to run aimlessly along some bell-wires, and then out through a window-frame, and down a spade or something propped up against the wall to earth. The lightning tester comes with his galvonometer and Leclanché cell, and reports that the earth of the conductor has 100 ohms resistance; and the accident is therefore accounted for. But how much resistance would he have found in the paths which the lightning seemed to choose in preference to the 100 ohms? Something more like 1,000,000, probably. Or perhaps there is a bad joint in the conductor somewhere, the parts being separated by one-sixteenth of an inch. But why should it prefer to jump several yards, and knock holes in walls and windows, rather than jump one-sixteenth of an inch? No; the galvanometer, and

Wheatstone's bridge, and Ohm's law, and conductivity, are simply not in it.

Something has been left out of consideration, and something very important, too; and until that something is fully taken into account no satisfactory and really undeniable security can be guaranteed.

That something is inertia—electrical inertia. Suppose you have a pipe or U-tube full of water, used as perpetual overflow to a cistern, and you want it to be equal to all demands. You test it, and find it perfectly easy to pour the water either way; both ends are perfectly open; the pipe is a good conductor. Then comes someone and hits the stagnant water in your pipe a tremendous blow with a hammer, bursts the pipe, and scatters the water all about. That is what lightning does to your lightning conductor and to the electricity in it. It is no gentle push, it is a terrific blow.

Conductivity is not what you want; widening the pipe is no remedy. There is a something you want; there is a remedy.

The remedy is elasticity—electric "capacity." You must reduce the electrical inertia (or self-induction) of your conductor as much as possible, and you must increase its electric elasticity (or capacity) wherever convenient. These are matters concerning which I have many experiments to show next week.

BRADFORD ELECTRIC LIGHTING.

The following is practically the full text of the discussion in this matter at the meeting of the Council last week:—

A communication which had been received from the Local Government Board with regard to the electric lighting scheme for Bradford was read by the Town Clerk. The communication was to the effect that the authorities had had under consideration the council's application for borrowing powers for the purposes of the scheme, and now sent down an authorisation for the council to borrow £20,000.

Alderman F. Priestman (chairman of the Gas Supply Committee) moved the adoption of the minutes of that committee, which included resolutions accepting the tender of Messrs. J. and W. Beanland for excavating, brickwork, ironfounder and smith's work, masonry, carpentering, joinery, plumbing, glazing, &c., in connection with the electric lighting works, for £3,690; the tender of Messrs. Holdsworth and Sons for the supply and fixing of three mild-steel boilers and fittings for £2,125; and the tender of Messrs. Siemens Brothers and Co., Limited, for the supply and fixing of dynamos and all the appliances for £12,543; the total cost of the proposed installation being £18,358. Further, the committee recommended that the council should authorise the Gas Supply Committee to apply to the Local Government Board for authority to increase the sum to be borrowed for electricity works to an amount not exceeding in the whole £25,000. Alderman Priestman said he did not think it necessary to go at any great length into the details of the proposed scheme, inasmuch as it was practically the same scheme as that which had been brought before the council in December last, when they had passed a resolution authorising the Gas Supply Committee to spend not more than £15,000 upon the scheme. That resolution was confirmed on February 14th, when the council instructed the Town Clerk to apply to the Local Government Board for leave to borrow £20,000 to carry out the scheme. In moving the resolution in December last he had promised the council that no money should be spent unless the council had first had the fullest information which it was in the power of the committee to give, and, therefore, it seemed to him to be due to both the council and the committee that he should now describe step by step every course which the committee had taken, in order that they might ensure that whatever money was spent had been expended well and without waste. Immediately after the passing of the resolution in December the Gas Supply Committee determined that, in addition to having the report from Mr. Shoolbred, they would consult the eminent electrician, Dr. Hopkinson, who was called upon to come to Bradford and see Mr. Schoolbred's report. Dr. Hopkinson came to Bradford, and had several hours' consultation with the committee, and went over the ground, in order that they might, when they had finished the consultation, feel quite sure that they were taking a right step. There was a general concurrence between the opinions of the two specialists, and upon points upon which they differed each gave way slightly. The only difference of real importance was as to whether the two-wire or three-wire system should be adopted, but in the end it was arranged that first of all the former should be put down, as it was acknowledged to be simpler than the latter, and so that if the installation were afterwards extended the three-wire system could be easily adopted. Not satisfied merely with the report of Dr. Hopkinson, the committee decided to see for themselves a number of instalments in different parts of the country. They saw the instalments, and then came to the conclusion that in following the advice upon which they were acting, they had taken the wisest course which they could have done. Mr. Shoolbred was invited to prepare detailed specifications of his proposed scheme, and then tenders were invited. A public inquiry was subsequently held by an inspector of the Local Government Board, and, as proving the interest which the public took in the matter, he (the speaker) might state that, with the exception of two members of the committee and three reporters, only one person was present who was not directly engaged in the inquiry. The tenders had been determined upon. Messrs. Siemens and Co., Limited, were providing the whole of the electric appliances, including the dynamos and fittings, and were to superintend and manage the works for a period of six or eight weeks after the latter were completed. The total amount of the tenders came to £18,358. To that they must add £2,000 for contingencies, and that brought the total up to over £20,000. The small balance of £5,000 would be required for the carrying on of that important work. The reason why they were asking for more money was that the installation was to cover a somewhat larger area than that which had been proposed in the first instance, and, further, because the works were to be of a permanent, and not of an experimental character. The committee had felt as they had gone along that what they doing would be of a permanent nature, and that they would rather have to extend their installation than give it up. Everything had been done with a view to the future, and so that if, in the course of time, it was found necessary to double the installation, it would be done at a very much smaller cost than the present work. Another circumstance which had operated against the committee was that since the installation had been determined upon a large syndicate which had been formed in Paris had driven the price of copper up to nearly double what it then was, and the difference in the cost of the necessary copper would amount to £1,000 or £1,500. The committee had felt convinced that to put down an installation of less than 3,000 incandescent lamps of 16 candle-power each would not give a fair test or proof of the success of this undertaking, and it was that reason which had induced them to bring before the council that resolution. He hoped that the council would pass the resolution with practical unanimity, and thus strengthen the hands of the committee, who had had the work thrown upon them because public opinion seemed to be tending in the direction of having a supply of electric light from somebody or other. If the Corporation had not gone on with these works, he believed that there were others quite prepared to do so, and that he would regard as a misfortune. He had every reason to hope and believe that the installation would prove to be an entire success.

Mr. David Barker seconded the resolution. He was not, he said, prepared to say that the success of the scheme was certain, but it was evident that the Corporation must do it or someone else would, and he thought it was proper that they (the Corporation) should do it.

Mr. Galloway spoke against the resolution. He said that when the scheme was first mooted the cost was to be from £10,000 to £12,000. From these sums the amount rose to £15,000, and now the chairman of the Gas Supply Committee asked for £20,000. His opinion was that the chairman had such large ideas about this thing and that, he could not be content with a small scheme. If the matter went on at this rate they would soon be asked for £25,000 or £30,000. He would like to tell both the chairman of the committee and Mr. Shoolbred that they were starting upon something that they knew very little about, and he believed that these gentlemen would be somewhat surprised before the work was finished. They had, he believed, a provisional order for Bradford—a thing which he did not believe any other Corporation in England had got. Whenever the question of electric lighting had come up their respected town clerk had something to say about it. They must not have any other bodies interfering with them—one king in a town was quite sufficient but he thought he was right in saying that the town clerk had been very badly troubled to think that the scheme might be dropped. There were large towns like Leeds, Hull, Sheffield, Huddersfield, and Halifax without provisional orders, and did they find any company trying to go into these towns with the electric light? No. And what did this mean? It meant that there was no profit at the back of electric lighting schemes. There was nothing but loss. He had heard one member of the council say that it would not much matter if they lost money by the electric lighting scheme, because £1,000 a year could easily be taken from the gas profits. The gentleman who said this wanted looking after. If they were going to swallow up the only Corporation business that paid, then it was time somebody looked into the matter. It had been stated that it would cost £50 to light a five-roomed house. If this were so, then he thought that not many dwelling-houses would use electric light; he thought it would only be used for outside illumination in order to attract attention. He would like the matter to be referred back to the committee for consideration; but if the chairman was determined to go on with it, then he ought not to exceed the £20,000.

The **Mayor**: May I ask if Mr. Galloway wishes to move a resolution to that effect?

Mr. Galloway: I don't think I could get a seconder (laughter).

Mr. T. Priestley expressed his belief, as the result of personal experience, that if people once got electric light into their houses they would not voluntarily return to gas.

Mr. Lobley thought that the Gas Supply Committee were entitled to the thanks not only of the council, but of every right-thinking person in Bradford.

Alderman F. Priestman, in reply to questions, said he hoped the installation would be quite complete by next Christmas. Continuing, he said that circulars were now ready to be sent out to every tradesman and resident upon the line of route of the proposed installation. The circulars offered to supply the electric light, and from questions which had been asked of him he apprehended that they would have a very large number of consumers. He felt that the scheme would be successful if applied only to the Corporation public buildings, without having regard to supplying private consumers. Even if they did not spend money on electric lighting, they would soon have to spend it on additional gas supply, for the time would come when the present gas works would have to be extended to meet the increased demands which would be made upon them.

The minutes were then adopted, with two dissentient votes.

Eastern Extension Telegraph Company.—The Directors of the Eastern Extension, Australasia and China Telegraph Company, Limited, have declared an interim dividend to the quarter ended March 31 last of 2s. 6d. per share free of income-tax, payable on July 14 prox.

COMPANIES' MEETINGS.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY.

The seventh annual ordinary meeting of this Company was held on Friday, June 8, Mr. C. L. W. Fitzgerald presiding.

Mr. C. Curtoys, the secretary, read the notice convening the meeting.

The **Chairman** moved the adoption of the report, which showed a balance in favour of profit, including that brought forward, of £12,484. It was proposed to write off a total sum of £2,541, and to pay a further dividend of £2. 17s., making, with the interim dividend, a dividend for the year of £5. 7s. The Chairman referred to several subjects of interest to the shareholders, and said he looked for an increase of telephone business from the proposed fusion of all the companies in the country.

The report was adopted, and the dividend declared.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.

The third annual meeting of this Company was held on the 7th inst.

The **Chairman**, in moving the adoption of the report, having drawn attention to the increased business of the Company, pointed out that there was an increase of no less than 84 per cent., and a large proportion of this wire extension was on trunk lines, chiefly in South Wales, where there was a very important territory, which it was desirable they should occupy as soon as possible. The cost of trunk lines had been nearly £19,000, and the rentals were at first very small, so that this outlay had been nearly unremunerative, and at the same time there had been interest to pay. But already the trunk income was coming in rapidly, and amounted to about £1,300. The total trunk calls now amounted to very nearly 10,000 a month. In September, when the trunk system was first set going, the calls were something over 5,000, and now they were nearly 10,000. Their longest line at present was that from Bath to Llanelly, a distance of about 142 miles, and, generally speaking, the messages were satisfactorily heard. The balance would have admitted of a small dividend, but the Directors, although confident of the future, advised carrying the balance to next year, making up the reserve fund to a round sum of £1,000. The general business grew rapidly, and very few weeks passed without some special suggestion. They would notice a desire had been expressed to connect London and Birmingham with the trunk wires and the system generally. Their experience showed there was a very great indirect advantage from trunk wires, not merely from subscribers' and trunk calls, but by adding very materially to the exchange subscribers in the various towns. During the year trunk and renters' wires had increased to the number of 977 miles. One interesting extension they were looking forward to, and that was a proposal to connect Eddystone Lighthouse with Plymouth. This was not only desired by the Admiralty as giving an opportunity of connecting the dockyards with the lighthouse, but it would be of great use to the mercantile marine as a signal station to the ships passing. If they could see their way to a fair return on the outlay, he thought this extension might very soon be carried out. He would mention that there was a desire that the coastguard stations, and possibly some of the lifeboat stations, should be connected. At present they could not see where the income would be derived in order to meet the large expenditure which would be incurred, but if a connection was necessary the telephone was by far the best medium which could be utilised.

It was resolved that a dividend of 6 per cent. be paid to preference shareholders, and the retiring Directors were re-elected.

PROVISIONAL PATENTS, 1888.

SEPTEMBER 14, 1887.

12,437A. **Electrical measuring instruments.** Rookes Evelyn Bell Crompton and James Swinburne, Arc Works, Chelmsford. Note.—This application having been originally included in No. 12,437, dated 14th September, 1887, takes, under Patents Rule 23, that date.

JUNE 8, 1888.

8401. **Improvements in electric batteries.** Edward William Clifton and Valentine Robinson, 47, Lincoln's-inn-fields, London.

JUNE 9.

8457. **Improvements in telephones.** Lemuel Mellett, 55 and 56, Chancery-lane, London. (Complete specification.)

8496. **Improvement in electro coating metals with zinc.** John Lea and Henry Rossi Hammond, 166, Fleet-street, London.

8503. **Improvements in magneto-electric fuses or exploders.** Eugène Ducretet, 45, Southampton-buildings, London.

JUNE 11.

8525. **Improvements in electric trembling bells.** Frederick Lawrence Rawson and Philip Jolin, 11, Queen Victoria-street, E.C.

JUNE 12.

8596. **Improvements in automatic telegraphy.** James Yate Johnson, 47, Lincoln's-inn-fields, Middlesex. (Edward Jones Mallett, United States.) (Complete specification.)

8611. **An improved form of galvanic belt for medical purposes.** William Laughton, 188, Camden-road, St. Pancras, N.W.

JUNE 13.

8657. **Improvements in dynamo-electric machines.** Henry Barcroft, 6½, Waring-street, Belfast.

JUNE 13.

8673. **An improved reflecting telemeter.** William Smith and Robert Gordon Nicol, Aberdeen.

8697. **An improvement in mariners' compasses.** James Sandeman, 53, Chancery-lane, London.

8700. **Improvements in and relating to electric batteries.** Louis Marie Joseph Charles Clement Renard, 45, Southampton-buildings, London.

JUNE 14.

8724. **An improved appliance or switch for electrical machines or apparatus.** William Snelgrove, 77, Colmore-row, Birmingham.

8746. **Improvements in plating metals with aluminium and producing alloys thereof.** Léon Quentin Brin, 53, Chancery-lane, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

JUNE 18, 1887.

8795. **Improvements in galvanometers with suspended coils.** William Edward Ayrton, City and Guilds of London Central Institution, Exhibition-road, London, and John Perry, City and Guilds of London Technical College, Finsbury.

JULY 21, 1887.

10,233. **A novel combined electrical vapor bath.** Muriel Maitland, Gray's-inn-chambers, 20, High Holborn, London, W.C.

JULY 26, 1887.

10,381. **Apparatus or means for preventing more than one electric shock being given after the insertion of a coin into automatic or other machines in which electricity is employed.** William John Wo dward, 45, Southampton-buildings, London, W.C.

AUGUST 11, 1887.

11,004. **Improvements in apparatus for the electrical propulsion of tramcars and other vehicles.** Michael Holroyd Smith, 28, Southampton-buildings, Chancery lane, London, W.C.

NOVEMBER 30, 1887.

16,473. **An electrical signalling device for railway purposes.** Samuel Sidney Bromhead, 97, Newgate-street, London, E.C. (Samuel T. Street, United States.)

FEBRUARY 9, 1888.

1932. **Improved forms of electrical contacts for switches and similar fittings.** Frederick Henry Royce, Blake-street, Hulme, Manchester.

MARCH 27, 1888.

4673. **Improvements in dynamo electric machines, and in regulating and measuring apparatus for use with same.** Philip Middleton Justice, 55 and 56, Chancery-lane, Middlesex. (Charles Heisler, United States.)

APRIL 3, 1888.

4964. **Improvements in apparatus for transferring electric currents.** Alfred Julius Boult, 323, High Holborn, Middlesex. (Stefan Doubrava, Austria.)

SPECIFICATIONS PUBLISHED.

1887.

6809. **Electric bell indicators.** J. and E. Eshelby. 8d.

6918. **Telegraphy.** W. E. Gedge. (Claude.) 1s. 3d.

7042. **Electric arc lamps.** F. G. Chapman and others. 8d.

9829. **Dynamo-electric machines.** T. Stanley. 8d.

9904. **Insulating coatings for electrolytic apparatus.** L. Grabau. 8d.

10,195. **Dynamo-electric machines.** J. P. Hall. 11d.

10,575. **Instruments for electric measurement.** W. Emmott and J. H. Rider. 6d.

15,717. **Electrical date and time stamp.** C. A. Randall. 1s. 1d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ending June 15 amounted to £4,760.

West India and Panama Telegraph Company.—The estimated traffic receipts of the West India and Panama Telegraph Company for the half-month ended June 15 were £2,931, against £2,792 for the corresponding period of 1887.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ending June 15, after deducting the fifth of the gross receipts payable to the London-Platino Telegraph Company, Limited, were £3,923.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
3 Jan.	4%	African Direct 4%	100	101
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	3¾
26 April	1%	Anglo-American	100	35½
26 April	2%	— Pref.	100	60
12 Feb., 85...	5/0	— Def.........................	100	12¼
28 Mar.	3/0	Brazilian Submarine.........	10	12½
16 Nov.	1/0	Con Telephone & Main ...	1	¾
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	20
28 Mar.	2/2½	Direct Spanish	9	4¼
28 Mar.	5/0	— 10% Pref.	10	9
28 Mar.	2/0	Direct United States	20	8½
12 April	2/6	Eastern	10	11¾
12 April	3/0	— 6% Pref.	10	15
1 Feb.	5%	— 5%, 1899	100	110
26 April	4%	— 4% Deb. Stock	100	106
26 April	3/6	Eastern Extension, Australasia & China............	10	12¾
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	103½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5⅝
12 April	3/0	— 6% Pref.	10	13⅞
30 April	5/0	Great Northern................	10	14¼

Dividend.		Name.	Paid.	Price. Wednesday
1 Mar.	5%	Gt. Northern 5% Deb., '83.	100	109
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17½
11 May	37/6	Indo-European	25	38
16 Nov.	2/6	London Platino-Brazilian...	10	6x
16 Mar.	5%	Maxim Weston	1	⅛
26 April	2½	Oriental Telephone	11	⅜
26 April	4/0	Reuter's	8	8¼
......	...	Swan United	3½	2⅝
15 Feb.	15½%	Submarine	100	139
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	14½
......	...	West African	10	5
1 Mar.	5%	— 5% Debs.	100	92¼
29 Dec.........	6/0	West Coast of America ...	10	6⅛
31 Dec.	8%	— 8% Debs.	100	117
11 May	9/	Western and Brazilian......	15	10½
11 May	6/10½	— Preferred	7½	6⅝
11 May	2/1½	— Deferred..................	7½	4
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	107½
......	...	West India and Panama ...	10	1
30 Nov.	...	— 6% 1st Pref.	10	10⅞
13 May, '80...	...	— 6% 2nd Pref.	10	7½
2 May	7%	West Union of U.S.	$1,000	123
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.	Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...	Eastern Extension	M. of May ...	£40,586	+ £1,376
Brazilian Submarine	W. June 15 ...	£4,760	...	Great Northern	M. of May ...	23,200	...
Cuba Submarine..................	M. of May ...	4,437	+ £736	Submarine	None	Published.	
Direct Spanish.....................	M. of May ...	1,800	+ 119	West Coast of America	M. of May ...	4,700	...
— United States	None	Published.	...	Western and Brazilian	W. June 15 ...	3,923	...
Eastern..............................	M. of May ...	49,003	+ 8,446	West India and Panama	F. June 15 ...	2,931	+ 231

Abbreviations: W., week; F., fortnight; M., month.

NEW COMPANIES REGISTERED.

Luther Hanson and Co., Limited.—Registered by R. Jordan, 120, Chancery-lane, London, W.C. Capital £7,500, divided into 1,500 shares of £5 each. Object: the acquisition of the patent rights in connection with improvements in electric arc lamps, field magnets, and in dynamo electric machines or motors, now the property of Luther Hanson and Charles, of North Bridge Electrical Works, New Bank, Halifax; the working of the said patent rights, and the making, exercising, and manufacturing for sale of the articles produced thereby, and the carrying on the business of electrical engineers and contractors; the supplying of electric light to towns, public and private companies, clubs or associations, mills, shops, warehouses, dwelling-houses, or other premises. The first subscribers are:—

	Shares.
J. Longbottom, Woodbottom Dye Works, Luddendon Foot.........	20
L. Ingham, Farrar Mill, Salterhebble	20
G. Charnock, contractor, Halifax	20
L. H. Anson, electrical engineer, Halifax	100
C. Dobson, clerk, Halifax	3
J. Farrar, solicitor, Halifax...	1
J. Duff, accountant, Barum Top, Halifax	1

The first Directors shall be J. Longbottom, L. Ingham, G. Charnock, and Luther Hanson. The qualification of the Managing Director shall be at least 100 shares; other than the Managing Director, no Director shall receive any remuneration for his services.

Automatic Electrical Corporation, Limited.—Registered by Messrs. Ashurst, Morris, Crisp, and Co., 6, Old Jewry, E.C., with a capital of £75,000, divided into 3,750 shares of £20 each. Object: to act as undertakers for the supply of electricity for lighting and other purposes within the United Kingdom and elsewhere. The first subscribers are:—

	Shares.
E. J. Hernandez, 7, Liverpool-street, W.C.	1
T. G. Koskseml em, 27, Phillome-place, Kensington	1
J. T. Blanchard, 25, Huntley-street, W.C.	1
W. Doherty, 6, Great Newport-street, W.C............................	1
E. Tritton, 8, Cammag-place, W.	1
R. G. Upton, The Canons, Mitcham	1
W. Sherratt, 461, Oxford-street	1

The first Directors shall be nominated in writing by the majority of the subscribers to the memorandum of association. The number of Directors shall never be less than three nor more than ten. The qualification of a Director shall be the holding of shares of the nominal value of £250, in respect of which all calls for the time being due shall have been paid; but in case a person not holding such qualification is appointed a first Director his appointment shall be void, but he shall, within one month from the date of appointment, acquire his qualification. The remuneration of Directors shall from time to time be fixed in general meeting.

The Petroleum Engine Company of America, Limited.—Registered by Maddisons, solicitors, 20, King's Arms-yard, London, E.C. Capital, £150,000, divided into 30,000 shares of £5 each. Objects: to acquire certain American (United States) patents for inventions in relation to petroleum engines, and with a view thereto to ratify and adopt the agreement between John Joseph Reveley Humes of the one part, and Ernest Whitehead (on behalf of the Company) of the other part, and to carry the same into effect with or without modification; to carry on, either in the United States of America, and elsewhere, as may be found expedient, the business of mechanical and chemical engineers, manufacturers of engines, and workers and dealers in electricity, motive power and light, and any business in which the application of electricity or any other power is or may be useful, convenient, or ornamental, or any other business of a like nature, and in the United States of America or elsewhere to manufacture and produce and trade and deal in electrical generators and accumulators, electromotive oil, gas, water, steam or other engines, and all or any kind of electrical and other apparatus and appliances, whether used or which hereafter may be used in connection with motive powers or illumination, and whether in connection with any invention now known or hereafter to be discovered. The first subscribers are:—

	Shares.
T. T. Curtis, cashier, 17, Triangle, Ruby-street, Old Kent-road, S.E.	1
G. T. Adams, clerk, 152, Fairbridge-road, Upper Holloway, N......	1
H. T. Adams, clerk, 106, Bayham-street, Camden Town, N.W.	1
W. Micklethwait, 34, Millman-street, Bedford-row, W.C............	1
C. Chilcot, schoolmaster, 39, Frederick-street, Caledonian-road ...	1
G. F. Tucker, stationer, 38, Kerrett-road, Brixton	1
E. Whitehead, engineer's clerk, 73A, Queen Victoria-street, E.C...	1

The number of Directors shall not be less than three nor more than nine. The first Directors shall be his Grace the Duke of Manchester, K.P., Sir Henry Cartwright, Knt.; Major Alexander Ross, M.P.; William Tipping, Esq.; Major-General W. O. Swanston; Robert O. Ritchie, Esq.; and Joshua Priestman, Esq. Each Director shall be a shareholder in the Company, and must hold at least 40 shares in the capital of it. The remuneration of the Directors shall be £200 per annum for each Director, and £100 per annum extra for the Chairman of the Board, and such further sums (if any) as shall be voted by the Company in general meeting.

NOTES.

Kensington.—Kensington Parish Church was lighted last week by the incandescent electric light.

Dr. Mann Lectures.—Prof. Oliver Lodge's "Mann" lectures on the "Protection of Buildings from Lightning," which we are reproducing, will shortly be published in book form, with additional matter, by Messrs. Whittaker and Co.

Marseilles.—The Marseilles Gas Company run arc lamps as well as gas. The lamp-posts are triple, with an arc lamp above, and two gas jets below. The arcs run till midnight, and afterwards the gas comes in for its share of the lighting.

Belfast.—The premises of the well-known firm of Messrs. Robinson and Cleaver, linen manufacturers, Belfast, have been lighted with the incandescent electric light by Messrs. Greenhill. The light created a good deal of enthusiasm in the district.

Communication with Lightships.—Several of the largest New York shipping merchants, says the *Electrical World*, are promoting a plan to e tablish telegraphic communication between shore and the lightships along the coast. It is hoped to carry out the scheme by the summer of 1890.

Milan.—Milan has 130 arc lamps running. Seventy more are to be added shortly. These new lamps, like those previously ordered, are on the Thomson-Houston system. The dividend declared by the Company has been 4 per cent., as against 1·6 per cent. before the Thomson-Houston system was adopted.

Turin.—Messrs. Bellani Fratelli have secured, under a fairly reasonable royalty to Government, the concession for central station lighting in Turin for a period of twenty-seven years, and have about 100 Thomson-Houston arcs running. This firm have also the sole right in Italy for use of the Thomson-Houston system.

City Guilds' Calendar.—The new programme and calendar of the City and Guilds of London Institute for 1888-9 has been issued. It contains the regulations for the technological examinations for 1889, syllabus of subjects, and recommendations of books of references. It also contains the papers set at the examinations of the present year.

Alternate Current Motors.—With reference to the recent discoveries by Dr. Ferrari and Nikola Tesla in the direction of alternate current motors, the question of prior invention is cropping up already. We learn on good authority that Prof. Elihu Thomson has had an alternate current motor running in his laboratory for the last twelve months or so.

Silica in Accumulators.—M. Hignette, an engineer in Paris, proposes to separate the different electrodes of an accumulator by a plate of pure silica. This disposition, he states, would have the advantage of rendering contact between the electrode impossible, without increasing the resistance, owing to the great porosity of the silica employed. Silica is a material of which we do not as yet fully know the properties, and it may be worth while for it to receive the further attention of the electrical chemists.

New Incandescent Lamps.—Recent announcements that have appeared showing that the proprietors of the Sawyer-Man system, and also the owners of the Seel patents, contemplate establishing works in England, looks very much like having keen competition amongst suppliers of incandescent lamps. We learn that both Mr. H. C. Davis, president of the Sawyer-Man Electric Company, and Mr. Zacharias, representative of the Seel system, are at present in England carrying out negotiations on behalf of their respective systems.

No Zinc Used.—With reference to what it calls the ridiculous pretensions of D'Humy, a French contemporary gives the following anecdote: At a certain exhibition an inventor of a primary battery assured the unsuspecting public present that his particular battery consumed very little fluid, and *no zinc*. Some specialists, happening to be present, naturally enquired, "What do you have the zinc at all for, then?" "Just to show that none of it is used, I suppose!" said another bystander, while the inventor was casting about for his reply.

St. Bernard.—An interesting and useful application of modern science to the remains of mediæval institutions, is that of a telephone which has just been fitted between the Hospice on the Great St. Bernard, and the station in the valley below. The monks are informed when travellers are ascending the pass, and if they do not arrive at the right time, the monks can go to meet them. It has already proved of considerable assistance, six lives having been saved recently, the last two rescued being travellers who were lost in the snow fully two miles away from the Hospice.

Medical Electricity.—Our readers must be careful to note that the *soi-disant* British Association (!) of Medical Electricians, which Mr. C. B. Harness, of quack belt fame, has formed principally from the staff of his own showroom for commercial purposes, has no connection whatever with the Institute of Medical Electricity, formed under the guidance of Mr. H. Newman Laurence, A.S.T.E., which is distinctly established for the purpose of opposing such misleading and unscientific enterprises, and of gathering information and providing facility for the real knowledge of electricity, as it can be applied in medical science.

A Revolution in Steam Production. — Mr. Fletcher, Chief Inspector of Alkali Works, in his annual report, just issued, deals with a number of subjects of great interest to manufacturers. His remarks upon Mr. Hargreaves' hot-air engine, or thermo-motor, are specially important. He says that it will not only effect the prevention of black smoke, but promises to revolutionise our methods of producing power. An energy of 40 h.p. can be maintained with the expenditure of two gallons of coal-tar or 45lb. of coal per hour. Either liquid fuel or coal can be used. This is a result three times more favourable than that realised by the best, and five or six times more than by ordinary steam-engines.

Burying Magnetised Watches.—Dr. W. H. Pulford, of Ansonia, Conn., had a valuable watch apparently spoiled through getting magnetised by a dynamo. He tried to devise some way of remedying the difficulty without going to a heavy expense, and hit upon this plan. He enclosed his watch in a cloth bag, and buried it in a large box of damp earth, where it remained for three days. He then dug it up, and found that the watch was completely cured. The simplicity of the process commends itself to owners of magnetised watches, who may be thus able to effect a cure without recourse to jewellers. Their only care must be to

recollect where they bury them, or we may be having an increase of treasure-trove.

Electric Heaters.—Richmond, Virginia, has electric heaters at work, and they will shortly be fitted on the cars of the electric railroad. The office of the company is heated by this means at the present time. The heaters are connected four in series, the street wire being tapped to supply the current. The current is turned on in the usual way, with a small switch in the room, and the electrical energy required is about three-quarter h.p. for a heater to warm a room 15ft. square. The double conversion of heat into electricity and back has a very low efficiency, and will have a very limited use. Railway carriages are, perhaps, as good an example as any, as a small, constant, and harmless source of heat is required. The energy might be obtained (as now for electric light) from the axle of the carriage. For the electric tramcars the main current might be available for winter use.

Thomson-Houston Company. — The Thomson-Houston Company of America are doing big business. They have fitted up 150 lighting stations for local companies during the past year—that is, at the rate of three lighting stations per week, many being towns of less than 5,000 inhabitants. They have fitted 37,000 arc lamps; 78 stations, taking 48,000 incandescent lamps, and 23 stations with 11,000 lights, with alternating apparatus. This is not including private buyers, which would make the amount nearly double. For the New York extension of lighting they will supply 2,250 arcs, with the probability of doubling the number. Three companies are doing this extension work in New York, who between them will require this number of arcs, the manufacture of which will be by the Thomson-Houston Company. This is besides about 3,000 arcs at present running in Brooklyn.

Electro-Plating.—We have received a copy of the second edition, carefully revised, with additions, of Mr. J. W. Urquhart's "Electro-Plating: A Practical Handbook." It is clearly written, well arranged, and is aimed to obtain, with the greatest possible simplicity of language, the providing of working directions applicable to the practice of the plating-shop, and to the requirements of amateurs. Electro-plating is gaining a continually-increasing practical value in commercial fields, and has, besides, a fascination for amateurs, by the ease and beauty of its results. In this work we have not a mere text-book compilation, but a practical treatise, carefully worked out from the author's own experience—exactly the kind of book for technical use we are often asked for in various electrical departments and are not always able to mention. The whole of the details necessary for plating by batteries is gone into, with practical directions for each process; the deposition of copper, gold, silver, and nickel being described in separate chapters. The new processes of nickel-plating are fully described, and the use of dynamo machines is also carefully considered.

Barcelona.—The magic fountain, which was seen for the first time in the Health Exhibition in 1884, and later in the Inventions and Colonial Exhibitions, and which has been reproduced in Liverpool, Staten Island (New York), and also at the Glasgow Exhibition of the present year, is attracting great notice in the Barcelona Exhibition. The fountain at this exhibition considerably excels all the others. The motive power which is employed when all the jets of water and projectors of the electric light are at work is not under 300 horse-power. The fountain was constructed by the Anglo American Brush Corporation, who are represented in Barcelona by Don José S. Noble, and the work has been under the management of Mr. William Bates, acting on behalf of the above-named firm. The fountain was completed in a very short space of time, considering the great difficulties which had to be encountered in the course of erection. The effects of the light are produced with very little manipulation of the lamps, and the whole makes an extremely fine and delicate display. Mr. Raworth, the chief engineer, went expressly to Barcelona for the official opening ceremony.

Electric Welding.—Electric welding has now been put on a commercial basis in America, according to the Boston papers. A company has been formed mainly by Boston capitalists, with a capital stock of half a million, which will turn out welding machines. The machines will be sold, but the company has also a royalty on every weld made by their machines. To make this practical, a meter is set upon them all, in the manner of the sewing-machine royalties in America, so that the inventors may reap some of the benefit of the process to the users, besides the mere sale of the machine. The meter has three dials, resembling those on a gas meter, and by its peculiar construction it is claimed that it will not register unless a perfect weld is made. These machines will weld anything in the shape of metal. They do not require that both metals shall be of the same material, as iron has been welded to brass in the experiments tried. The machines as they are now built will weld an iron cable or a watch-spring with equal readiness, and it may be even contemplated that propeller-shafts may be welded by this means. It is claimed that the process makes a perfect weld by fusing the metals, and does not burn the metal, as is often the case in the Bernados process.

Summer Course of Lectures.—Prof. W. E. Ayrton, F.R.S., will give a thorough practical course at the Central Institution, South Kensington, on "The Construction, Testing and Use of Electrical Measuring Instruments." This course will include experimental lectures and special laboratory work, and will be specially adapted to the makers of electrical measuring instruments. The lectures will comprise the principles and practice of the construction, calibration, and testing for faults of ammeters, voltmeters, ohmmeters, wattmeters, coulombmeters and ergmeters as used for direct and alternating current systems. The students' practical work will be conducted in a laboratory specially fitted with accumulators, standard instruments, &c., for electrical instrument testing, and they will have the opportunity of examining and practically trying all the more important electrical meters at present in ordinary use. The course will extend over two weeks, and will consist of six lectures, from 8 to 9 p.m., on Mondays, Wednesdays and Fridays in the fortnight commencing on Monday, July 16th; and also of practical work in the physical laboratories, daily, Saturdays excepted, from 2 to 5 p.m., commencing on Tuesday, July 17th. Applications for admission should be received not later than July 6th.

Electrostatic Transformers.— According to the *Electrotechnische Anzeiger*, No. 16, 1888, Dr. Doubrava, late pupil under Profs. Stefan and Mach, and teacher at the Technical High School, at Prague, has patented transformers in all countries, which are dependent not upon electro-magnetic but upon electro-static induction. These transformers can be used with direct or alternating currents, and for any desirable difference of potential. With direct currents, a "disjunctor," worked by a small electromotor

enables a condenser to be charged from the central station by a high pressure wire, and from the same "disjunctor" the secondary current is produced by means of a second condenser, and any desired reduction of pressure can be obtained. By this transformation, when the speed of rotation of the disjunctor is arranged so that the condenser is charged and discharged at the same instant, not the slightest spark occurs. With alternating currents, two plates are charged by the high-pressure wire, which influences two other plates, and from the latter the secondary current is obtained. The efficiency is said to exceed that of the electromagnetic transformers, and the system is shortly to be introduced in practical work for electric lighting. We shall be interested to hear whether anything practical comes of this invention, which professes to be an entirely new departure in electric light transformers.

Electromotive Force of Cells.—M. Meisler, an Austrian physicist, has measured the electromotive force of various cells with the aid of Siemen's Universal Galvanometer and a standard Daniell cell. He has communicated the following results to the Academy of Sciences at Vienna, which will be useful for reference :

	Volts total E.M.F.
Daniel standard cell	1·06
Grove	1·62
Bunsen	1·77
Bunsen chromic acid	2·18
Grenet	2·02
Smee	1·06
Lalande-Chaperon	1·17
Leclanché	1·68
Marie-Davy	1·50
Warren de la Rue	1·07
Niaudet	1·65

M. Meisler has also studied the variations of potential during charge and discharge of the various parts of the Planté accumulator, of which he gives the total E.M.F. as 2·2 volts. During discharge, the difference of potential between the positive electrode and the acidulated water diminishes in a regular manner, until the E.M.F. of the element has fallen below half its normal strength. On the other hand, the difference of potential between the negative electrode and the liquid diminishes rapidly, and even changes its sign at the end of a sufficient period of time.—*Revue Scientifique.*

Barnet.—The preparations for the lighting of the town of Barnet are proceeding, but there has been some hesitation on the part of the authorities as to the power of the lamps. The incandescent system was decided upon for the street lighting, and 16 c.p. was thought to be enough, being as much as the present lamps. Mr. Joel, however, has been trying to convince them that 16-c.p. lamps will prove a failure, as was certainly the case at Leamington, and proposes 32-c.p. lamps, with a few stronger lights at main corners, and experimental trials were made last week to test the power of the lamps. Mr. Joel has secured the sole right for three years, with permission to use poles in the streets for the first twelve months, after which all wires are to be underground or at back of the houses. Besides the sole right for three years, he has stipulated that he is to have continual equal right with others at the expiration of this term to continue the lighting, if he so desires. The price fixed is £2. 14s. per 16-c.p. lamp per year, lighted from dusk to 12:30 a.m., and £5. 2s. till dawn; 32 c.p. double this price, and additional light in proportion. It is proposed to put in three engines eventually, one of which will be first installed. This will be 20 h.p. nominal, and the lamps will be in parallel series, fixed on special lamp-posts, with properly-designed reflectors for utilising the light to the best advantage. These lamps are to be lighted till 12:30, but the three larger lamps at a reduced light will be required all night, and to light these upon the same wire Mr. Joel proposes to insert a magnetic bye-pass to each of the main groups, which will drop when the speed of the engine is allowed to fall, leaving only the corner lamps alight, which will then be fed from a storage battery charged during the daytime. Further additions will, no doubt, be made for private lighting with transformers, as the demand increases, but the street lighting will be first carried out.

Thunderstorm Committee.—The first report of the Thunderstorm Committee of the Royal Meteorological Society "On the Photographs of Lightning Flashes," which has been drawn up by the Hon. Ralph Abercromby, F.R.M.S., has just been issued in pamphlet form. According to the results received, the typical forms of lightning are grouped under the headings of stream, sinuous, ramified, meandering, beaded, and ribbon lightning. Some very interesting photographs of the various types of flashes of lightning are reproduced. The society asks the cordial help of any interested in the question, either by sending copies of photographs already taken, and by endeavouring to take them, or by inducing others to do so. The results may be sent to the Secretary of the Royal Meteorological Society, at 30, Great George-street, Westminster. It may perhaps be well to mention that the photography of lightning does not present any particular difficulties. If a rapid plate and an ordinary rapid lens with full aperture be left uncovered for a short time at night during a thunderstorm, flashes of lightning will, after development, be found in some cases to have impressed themselves upon the plate. The only difficulty is the uncertainty whether any particular flash will happen to have been in the field of view. A rapid single lens is much more suitable than a rapid doublet, and it is believed that films on paper would effectually prevent reflection from the back. The focus should be that for a distant object, and, if possible, some point of landscape should be included to give the position of the horizon. If the latter is impossible, then the top of the picture should be distinctly marked. Any additional information as to the time, direction in which the camera was pointed, and the state of the weather, would be very desirable. The Society are hoping, now that the thunderstorm season is approaching, that many photographers, both amateur and professional, may be found willing to take up this interesting branch of their art.

Italian Exhibition.—The lighting at the Italian Exhibition, which is entirely on the Thomson-Houston system, has been considerably extended beyond the first requirements, and is admitted by both exhibitors and promoters to be all that is desired. The installing of the machinery was a very quick piece of work—only five days was allowed after the roof of the shed was on. The main galleries and refreshment rooms have 190 arc lights; the grounds and panorama 45, and the new annexe 20 arcs. The arena lately used by the Wild West is being fitted up as the Colisseum at Rome; this has 35 arc lights. Very shortly this will be opened for representation of Roman games, gladiator fights, and races. In the Marionette Theatre the incandescent lamps are being increased to 170, and the Welcome Club (a most luxurious, handsome, and convenient institution for exhibitors and their friends) is elegantly furnished by Messrs. Laing, Wharton, and Down with 60 incandescent lamps in burnished copper fittings.

An ingenious arrangement, used by the Thomson-Houston system, is shown in the engine-room offices and other places on the high potential arc wire. It is often required to put in a few incandescent lamps. When this is the case, a lamp is inserted in the main circit, taking an 8-ampere current. These lamps are made for 8 volts and 32 c.p., or 16 volts and 64 c.p., or 32 volts and 125 c.p., and can be inserted wherever desired in the arc circuit. The bye-pass for these is as simple as it is ingenious. The lamp is screwed into a socket, which communicates with the wire, but is only kept from short-circuiting by a thin piece of tissue paper soaked in paraffin. If the lamp breaks, this is ruptured by the main current, and the lamp is therefore cut out. On replacing the lamp by a new one, this latter does not light until the two plates are separated; a new piece of paper is slipped in, and all goes on as before. In America, the Thomson-Houston Company use these lamps by themselves largely in street lighting on a single high-tension wire; a small indicator at the station shows immediately if any lamps are out, and the attendant can then go round the circuit and replace them. We describe the Thomson-Houston incandescent dynamo used for this installation, with illustrations, elsewhere in our columns.

A New Electric Standard.—M. Marcel Deprez has devised an instrument for giving at will an invariable quantity of electricity—for example, the coulomb. It consists of a glass tube of U shape, having its two legs closed and terminated by glass bulbs of much larger volume than the cylindrical parts. One ball and its corresponding leg is filled with water acidulated with phosphoric acid. The second leg contains also some liquid below, but for most of its length it, and the ball ending it, is filled with air at a fixed pressure. The branch filled with liquid has four electrodes face to face in pairs, two at the upper part of the ball, and two in the cylindrical part a little below the lowest point of the ball. If an electric current is sent through these last, the water is decomposed, and the mixture resulting from the decomposition accumulates in the upper part of the ball, whilst the liquid is forced up the second branch, compressing the air in it. If the point of departure of the liquid column in the second branch is noted as well as the point it stops at when the current is stopped, all the elements necessary to know the quantity of electricity expended to produce the mixture of gases are forthcoming, and it is easy to see that if the volume of this mixture, measured by the ascension of the liquid in the second branch, is always the same, the quantity of electricity necessary to produce it will be equally invariable, whatever be the temperature of the instrument, provided it be the same in both branches—a condition easy to realise. The barometric pressure and hygrometric state of the air have evidently no influence on the results, since the tube is sealed like an incandescent lamp. In short, the apparatus produces at will a quantity of gas corresponding to the invariable quantity of electricity taken for standard, all the operation being the observation of the scale on the branch of the tube, and there being no correction to make. In order that the apparatus may continue to act indefinitely, the water is reformed at each operation by a spark passed through the detonating mixture of the gases in the ball. For this purpose the other pair of platinum wires is provided. The instrument may serve for the standardising of electric measuring instruments. It has been tested with great care by M. Minet, one of the engineers of the Creil experiments, and its indications compared with the ordinary voltameter, and found to be fully reliable.

Thermo-Batteries.—We publish this week an interesting and valuable communication by Mr. J. W. Swan upon Raub's thermo-battery, discussing the points under which its use may or may not be economical. Lord Rayleigh, at the British Association, has given what has proved almost a "quietus" to the question of thermo-batteries upon the score of efficiency, judged from standpoint of the laws of thermo-dynamics, stating that, as a heat-engine, for the limits of heat employed, the thermo-battery can never give a high efficiency, even when compared with a steam-engine. Prof. Silvanus Thompson, however, has pointed out that the thermo-battery is not to be judged solely as a heat-engine, and that the bare statement as above does not necessarily fully apply. The heat in the conversion of energy which takes place in the generation of electricity in the thermo-battery, or at least that portion of it which is so converted, never reaches the higher temperature at all; the greatest possible efficiency of the thermo-battery is when the greatest amount of heat disappears as heat and appears as electricity. There is this point to be kept in view, as contradicting Lord Rayleigh's result, and confirming Dr. Thompson, that the efficiency of the human body, or of a horse, is greater by far than the greatest possible efficiency judged solely as a heat-engine. Experiments have been made taking the weight of fodder consumed and the corresponding work accomplished by animals, and the result showed a far greater efficiency than that possible from the temperatures judged solely upon this law of thermo-dynamics. The question seems to point to the human body, and all animal power working upon other laws than that of the heat-engine—namely, that of the thermo-battery; and if we could prove that the thermo-battery has a *possibility* of a greater total efficiency than the boiler-engine-dynamo combination, the greatest stimulus would be added to the study of this means of generation. If the total efficiency possible, with a perfect heat-engine, is less than 40 per cent., of which we realise usually only about 10 per cent, and the total possible efficiency, with a thermo-battery, might be, say, 80 per cent., of which we at present realise only 2 per cent, this greater possibility will not be long in having advantage taken of it. Upon this subject we append the following clear and explanatory note by Prof. Perry, F.R.S., setting forth the result of the law of thermo-dynamics in the case of steam-engines and gas-engines: "We can prove that the greatest possible efficiency of any heat-engine cannot exceed $\frac{T_1 - T_2}{T_1}$, where T_1 and T_2 are the highest and lowest *absolute* temperatures of the working substance. T_2 cannot be less than 284 (or $10°C + 274$). Taking steam of 200lb. pressure per square inch as the hottest which may be used without burning the piston lubrication, this is 195°C. or $T_1 = 469$. The greatest efficiency possible is, therefore, $\frac{469 - 284}{469}$, or, $\frac{185}{469}$, or 39 per cent. In existing gas-engines T_2 is always high, usually more than 774; T_1 is, say, 1,774, and the greatest efficiency $\frac{1,000}{1,774}$, or 56 per cent. The necessarily great losses by conduction and radiation reduce these numbers very much indeed, so that the efficiency of the very best steam-engine and boiler is never greater than 15 per cent., and about the same for the very best gas-engine. Indeed, 10 per cent. is the common figure for good engines."

A NOTE ON RAUB'S THERMO-BATTERY.

The following is the substance of some communications which we have recently had with Mr. J. W. Swan, M.A., on the subject of Raub's thermo-battery, illustrated and described in this paper on April 13:—

In spite of the opinion, which has obtained large acceptance among scientific men, that the direct conversion of heat into electricity can never be an economical process, there nevertheless appear from time to time the results of fresh attempts at the solution of this possibly insoluble problem, and some of these are at least sufficiently interesting to deserve notice.

We are made aware of one of the latest of these attempts by a prospectus issued by Fuess, of Berlin, descriptive of "Raub's Patent Thermo-Battery." Looking over this prospectus we are struck with what appears as a distinct sign of of progress in the development of this species of electricity generator—viz., the largeness of the current producible by Raub's pile as compared with previous efforts. The apparatus advertised is of three sizes—to give a current of 10, 20, and 40 amperes respectively. Each of the e sizes is built up into a pile of 50 couples, and has an E.M.F. of 3 volts.

The three volts E.M.F., coupled with the large current, points to electrotyping and operations of that kind as the special purpose for which it is intended the thermo-battery should be used, and for such purposes there is no reason to doubt the statement of the maker that it is both efficient and economical.

Let it be granted that only something like 2 per cent. of the energy of the heat applied to a thermopile is converted into electricity, and that ten times the effect could be got out of the heat by means of a dynamo, it still remains a fact that it is a more economical generator of electricity than the ordinary zinc-consuming battery.

It may be worth while to go over the figures, and, since it is still seriously proposed to light incandescent lamps by primary batteries of various kinds, to inquire, without going into minute detail, what it would cost to light incandescent lamps on this discredited principle.

For this purpose, we will take the largest size of Raub's battery, which consumes 33 cubic feet of gas per hour and an E.M.F. of 3 volts, and gives a current of 40 amperes. We will assume that it is most efficient when the resistance in the useful work part of the circuit is equal to the resistance of the pile itself, and that therefore the available E.M.F. is 1½ volts, making a product of 60 watts. To obtain at this rate 1 e.h.p. (746 watts), the apparatus—and the gas consumption—would have to be multiplied thirteen times, the gas consumed per hour would therefore be 429 cubic feet. One e.h.p. would therefore cost 1s. 1d. with gas, at 2s. 6d. per 1,000 cubic feet. At 1s. 8d., which is the price of gas at Newcastle, it would cost 8⅔d.; and with Dowson water-gas, at 2⅔d. per 1,000 cubic feet (3½ times as much as of coal gas being used), the cost of an e.h.p. hour would be reduced to 4d.

But there is reason to believe (see a paper communicated to the Iron and Steel Institute on May 9, 1888, by Mr. A. Wilson, and based on very extensive practical working) that heating gas, of the nature of Dowson's gas—a mixture of hydrogen, carbonic oxide, carbonic acid, and nitrogen, obtained by blowing a mixture of steam and air through a column filled with fragments of carbon heated to incandescence—can be produced on a large scale at the cost of ½d. (one halfpenny) per 1,000 cubic feet, when the coke or coal employed in the process is 6s. per ton. As 1,500ft. of this gas would suffice for the production of an e.h.p. for an hour with Raub's thermo-battery, the cost at this rate would be ¾d. per e.h.p. This degree of economy is of course not realisable except where the mixed water and produced gases are obtained on a large scale and with cheap coal.

Burnt in an ordinary gas-burner, 3 c.p. is produced for every cubic foot of gas. The 429 cubic feet of coal gas supposed to be required to produce 1 e.h.p. hour through the thermo-battery and giving, say, eight 16 c.p. lamps, would give, therefore, in an ordinary burner 1,200 to 1,300 c.p., six to seven times the amount of light. But for the purposes of comparison we ought, perhaps, to take the best light that each can give—namely, the arc electric light, and the Wenham or Siemens gas light. In an arc lamp undoubtedly 1,000 c.p. can be obtained, often much more. Recent experiments have been made which go to prove that half a horse-power can be made to produce 1,000 c.p. in an arc lamp. With this extreme result, we might take 2,000 c.p. per h.p.; and with the Wenham or Siemens gas light, giving 5 c.p. per foot of gas, for the production of 400ft. of gas, we have also 2,000 c.p.

Used in a gas-engine, and with the power applied to a dynamo, this quantity of gas would produce ten times the e.h.p. With 150ft. of gas per hour in a gas-engine, 3 e.h.p. can be produced, or with 120ft. if the engine is in good condition; taking 40ft. to 50ft. per e.h.p., as against 400ft. to 500ft. used by the battery, we see that the dynamo costs one-tenth for gas. The first cost, also, of the dynamo plant is one third of that of the thermo-batteries. A gas-engine would cost £170, and a dynamo producing 2 e.h.p. can be obtained for £36—a total of £206. Twenty-six of the thermo-batteries, costing £22. 10s. each, will be required to produce 2 e.h.p., being a total of £585.

Electricity through Raub's thermo-battery is therefore ten times dearer in production than electricity produced by motive power. But often in electro-metallurgy and in many other applications the thermopile will have to compete with the ordinary galvanic battery. In comparing them with galvanic batteries they can boast an advantage, probably in the proportion of two to one, the cost of production of electricity by consumption of zinc being twenty times that of a dynamo driven by a steam engine. They have, besides, the merit of unusual constancy.

In what has hitherto been said no credit has been taken for the lost heat, which is not transformed into electricity. Looking at it this point, it does not seem at all an unlikely thing that an effective combination may be made of a thermo-battery and a heating-stove, and it is obvious that a successful combination of that kind would entirely alter the aspect of the question of the economy of heat-produced electricity.

One of the difficulties hitherto encountered in connection with the use of thermopiles is the destructive effect of the alternate expansion and contraction of the parts, consequent upon repeated heating and cooling. This difficulty, if it exists in the case of Raub's pile, might be met by adopting a suggestion made several years ago by Mr. Higgins, that the heating should be continuous and that the current from the pile should be made to charge a secondary battery used as an accumulator.

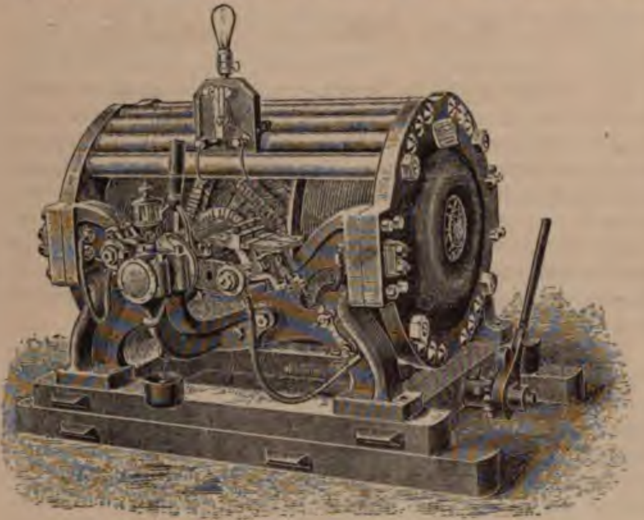
It has been reported that M. Heimel, a French electrician, has devised a thermo-electric couple with an E.M.F. of 0·18 volt, with a resistance of 0·009 ohm. This is a considerable advance on Raub's couple, fifty of which are required to give three volts. An improvement in this direction will tend to make the apparatus less costly; the present price also might very reasonably be expected to be considerably reduced, if the thermo-batteries are made on a manufacturing scale. If they could be produced at one-third the present price they would be equal (in the cost of apparatus) to an engine and dynamo, and this, looking at the development of electrical apparatus in other directions, is not an impossible supposition. There are evidently some uses for the thermo-battery even in its present imperfect form, and with further practical and scientific advances it may play an important part in the production of electricity.

THOMSON-HOUSTON INCANDESCENT DYNAMO.

A new dynamo, of a somewhat curious and novel type, is to be seen at the Italian Exhibition, where it is being used by Messrs. Laing, Wharton, and Down to supply the incandescent lamps in the Welcome Club and the Marionette Theatre. This is the Thomson-Houston incandescent dynamo, the only machine of the kind at present in England. This type of machine has been manufactured commercially for some time in America, but the one now running at the exhibition is the first sent over here.

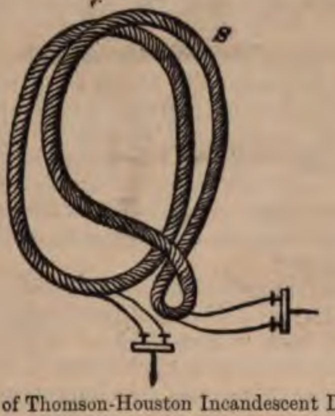
The Thomson-Houston incandescent dynamo bears some considerable exterior resemblance to the arc machine of

that name, and, like it, has distinctly novel points in its construction from that of other machines. It is compound-wound, but not in the manner covered by the Brush patents. The general appearance of the machine is seen in the accompanying illustration. The field-magnets are shunt-wound with fine wire, in the ordinary way of dynamos, and the armature is spherical as in the



Thomson-Houston Incandescent Dynamo.

Thomson-Houston arc machine. The series coils, however, instead of going round the field-magnets, are led off in two separate coils, between the poles of the magnets, and surrounding the armature. The main current passes through these coils in a divided current, half in each coil, and the magnetic induction furnished by these coils dis-



Series Coils of Thomson-Houston Incandescent Dynamo.

turbs the field of the shunt magnets in proportion to the strength of the current flowing, without affecting the actual strength of the magnets in the usual way. In this manner it compounds for any alteration of load. The appearance of the coils, which are just seen in the first illustration, is better indicated in the second woodcut. The top half of

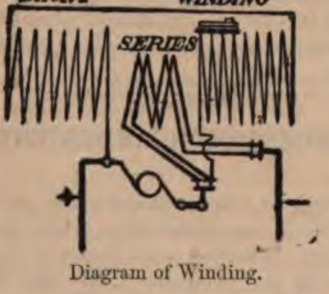


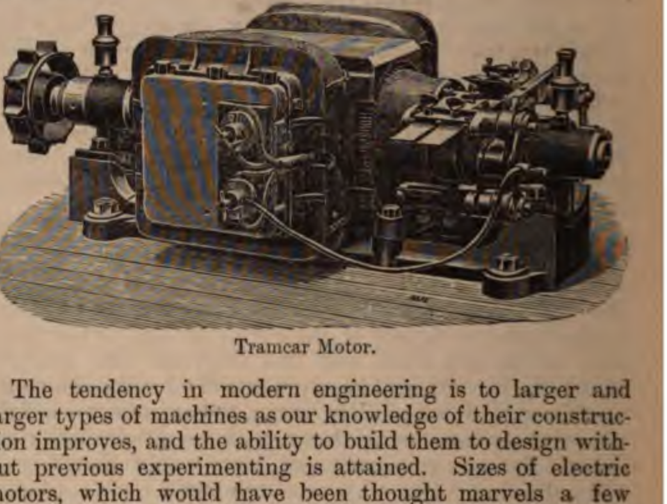
Diagram of Winding.

both coils pass over the armature—towards the left at the top and to the right at the bottom, the two separate cables dividing at one junction, and combining at the other. The general arrangement of the parts is shown by the diagram of connections showing the shunt and series coils.

This machine runs very steadily, giving very little trouble, and compounding for any number of lamps from 1 to 120. It is wound for 100-114 volts, a small regulator at the top cutting out some of the shunt coils, allowing of an adjustment, if necessary, to the extent of 14 volts, to allow for difference of speed. The commutator is quite smooth, and no sparking occurs. Of course, the automatic regulator present on the arc machines is not needed.

MOTOR WORK IN ENGLAND.

The production of motors in this country is proceeding apace, and although we cannot boast of the great development that has taken place in this branch of electrical engineering in America, where the factories for motors are as large as those for the production of dynamos, yet we can chronicle greatly increased activity, and the promise of the same development of large applications of this method of communicating power that has taken place in byegone years with other similar discoveries. Messrs. Immisch and Co., whose works in Kentish Town we have lately visited, are exceedingly active in all kinds of motors, large and small. They have in hand six motors to be used on the North Metropolitan Tramway Company's Barking line. A tramcar fitted with one of these motors has been running for some time on this line, and has given complete satisfaction. This type, of which we give an illustration, showing the sprocket-wheel gearing, is driven by accumulators carried on the cars. Two 100 h.p. dynamos for charging the batteries for this work are also being made by Messrs. Immisch and Co., and the number of tramcar motors to be employed for traction will be greatly extended after the first trials.



Tramcar Motor.

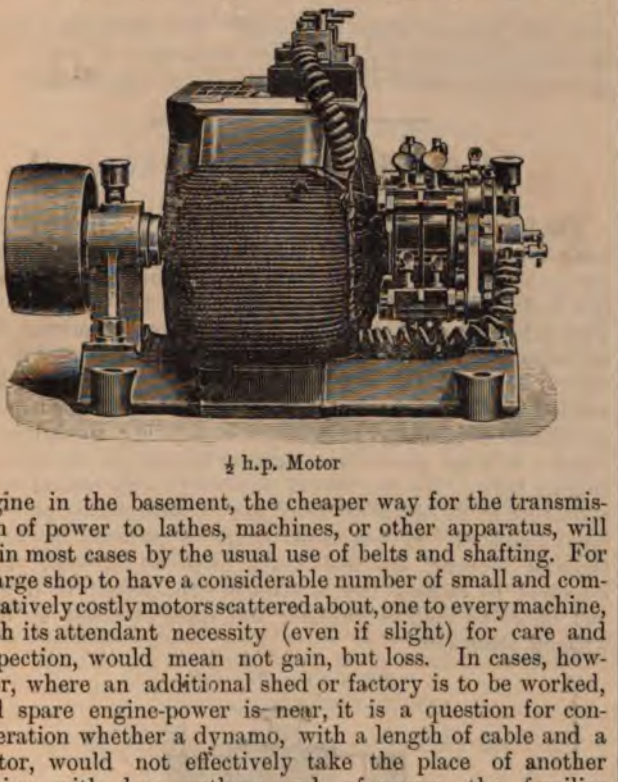
The tendency in modern engineering is to larger and larger types of machines as our knowledge of their construction improves, and the ability to build them to design without previous experimenting is attained. Sizes of electric motors, which would have been thought marvels a few years ago, are now ordered without much hesitation and manufactured without much difficulty, and we may confidently look to types of motors comparable in power to our large modern steam engine being satisfactorily produced as the demand for them arises. Messrs. Immisch are at present constructing two large motors for Messrs. Locke and Co., of Normanton. These motors weigh about four tons each, and will develop up to 75 h.p. when worked to their greatest power, though usually required for a regular output of 50 h.p. The field-magnets for these motors are of very large size, and for the double purpose of ease of conveyance and ventilation are made in separate sections. The motors themselves are too large to go down the shaft, at the bottom of which they are to be fixed, and will therefore be sent in parts and fixed together at the bottom. They will be used for hauling coal. The dynamos for supplying the current to these motors are of similar design, weighing a little more—namely, 4½ tons. The dynamos will be fixed at the pit mouth, and the current connected by cables down the shaft. Two large motors have previously been supplied for pumping the water from the pit, and the further order for hauling apparatus that has been secured indicates clearly the satisfaction this method of working gives the colliery proprietors.

With series motors—that is, constant current motors in series with lamps—not much seems to be doing in this country at present. Isolated plants, where a constant current is used for arc lamps, do not seem to be, as a rule,

much in need of a motor, and those stations running a constant current do not advocate the use of motors in series with their lamps, desiring to keep the light as steady as possible. Messrs. Immisch, however, have a type of constant current motor which they have manufactured in small quantities for some time; amongst others, one is running satisfactorily in the West of England, and one at Sheffield. This motor has an ingenious method of short-circuiting the current when the motor is not required. A pair of governor balls regulate by a lever arm a series of resistances, or rather the coils of the field-magnets, and upon the speed of the motor falling the regulator touches a spring, which causes a copper bar to fly out and short-circuit the machine.

In small motors Messrs. Immisch are continually busy, and keep a stock of the more usual sizes. These are produced of two man, ½, and one h.p. The ½ h.p. motor is a very compact and useful little motor, not very much larger than a hat, and weighs 42lb. It stands in any convenient corner, and is used for driving ventilators in factories or engine-rooms, or for other uses.

The question of where it would pay to use a motor, is one to which some attention should be paid. On the discovery of a new method of transmission such as this, many persons are naturally inclined, as occasion arises, to attempt a saving by the use of the improved method. It is only advisable in those cases where a distinct benefit can be produced. For an ordinary manufacturing shop, with a large



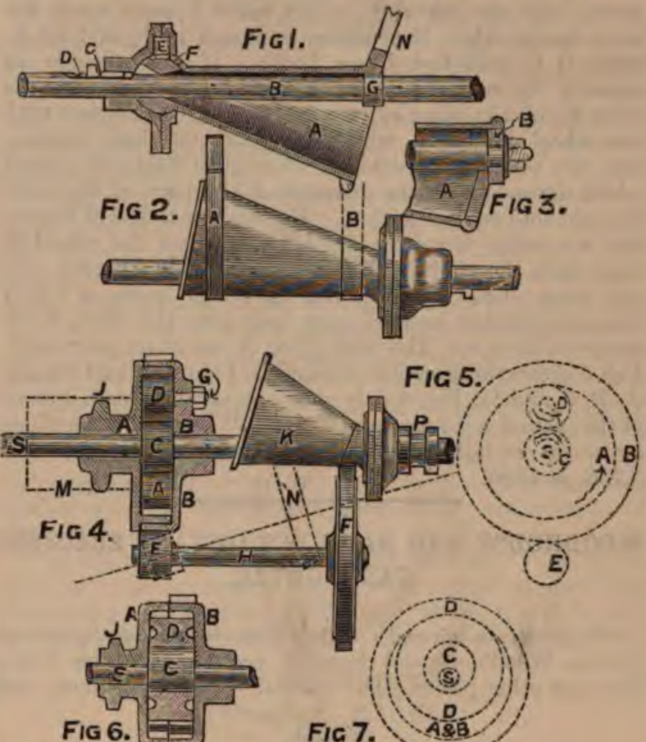
½ h.p. Motor

engine in the basement, the cheaper way for the transmission of power to lathes, machines, or other apparatus, will be in most cases by the usual use of belts and shafting. For a large shop to have a considerable number of small and comparatively costly motors scattered about, one to every machine, with its attendant necessity (even if slight) for care and inspection, would mean not gain, but loss. In cases, however, where an additional shed or factory is to be worked, and spare engine-power is near, it is a question for consideration whether a dynamo, with a length of cable and a motor, would not effectively take the place of another engine with less outlay; and, of course, the familiar example of a factory at some little distance to a fall of water is another situation in which the use of a motor would be most advantageous. But there is usually no advantage in putting in a motor merely to take the place of belts. Messrs. Immisch have a motor running in this way, driving the belts and shafting for two machine shops. The motor mentioned is of the tramcar type, giving usually about 5 h.p. to 10 h.p. It is wound for 160 volts, and takes 50 amperes at a maximum. The weight is 550lb. It has been running with every satisfaction for eighteen months. The original commutator is still beautifully smooth and bright, and has only been lightly skimmed once in the lathe. The brushes usually last about three months, and the motor is practically in the same condition (except for a little fresh paint) as when it was started.

The works of Messrs. Immisch themselves constitute a small power distributing station, several electric motors being hired out in the neighbourhood, the current being supplied from a dynamo, worked by the Marshall engine (indicating 120 h.p.) they have for their own works. A small motor works a ventilating fan for their engine-room, and a similar motor is used in the smithy. The printing machine at the back of Messrs. Immisch is run by a motor supplied in the same way, the rent of which the printing firm find considerably less than the cost of a steam or of a gas engine. Power is also supplied to several other small machines.

ELECTRICAL POWER ON TRAMWAYS.

In our impression of the 8th inst. we published a paper on the transmission of electric power by Herr Coerper, and an editorial article on electric tramways. In the former the author describes a form of motor applied to a tramcar, the object of the arrangement being the prevention of the necessity for using too big a current when starting, or to enable the motor to develop its full power when either starting the car, or when propelling it on an up gradient. In our article we called attention to the fallacy which underlies Herr Coerper's assumptions concerning the



device he describes. With the object of running the armature of his motor at a high speed when the car is starting, he mounts his field-magnets loose upon the armature spindle so that they also may rotate. Thus, when the field is left perfectly free, it rotates round the armature, and the car axle, with the armature stands still. On the other hand, when the field is prevented from revolving by means of a brake, the armature must revolve unless the resistance to its rotation is too great. Between these two extremes Herr Coerper proposes to obtain variable relative velocities for armature and field by permissive rotation of the field. He proposes to permit the field to slip at a greater or lesser velocity against the resistance of a brake. As we then pointed out, there was no gain whatever in this, for instead of the loss of speed in the armature being accompanied by a gain in turning moment on the car axle, the exact equivalent of the possible gain is thrown away in useless work upon the frictional brake surfaces. Since then we have referred to the *Electrical Engineer* of September, 1886, in which we published a short paper, which was read before the British Association by Mr. W. Worby Beaumont, describing a new system of imparting a variable velocity, and as one of the forms of the apparatus designed under the system was intended for tramcar work, perhaps we may usefully recur to its main features. The first object was to obtain the variable velocity without the loss of work, such as that which occurs with Herr Coerper's brake. The leading feature of the apparatus is the use of

what at the time was a new mechanical device, consisting of a hollow cone, mounted so that in one plane the surface of the cone and of the spindle upon which it was mounted were always parallel. Cones so mounted are shown on the accompanying engraving, as published in our impression above mentioned, and in which Figs. 1 and 2 show the cones as driver and driven by means of a belt. In Fig. 4 the cone is shown employed in controlling the rate of variation in variable velocity or epicyconoidal gear. Upon the shaft, S, which might be an extension of the motor spindle, is mounted the cone, K, in such a manner that it may be moved along the shaft, S, by a fork on the collar, P. On the same shaft are mounted loosely the internally-geared wheel, A, and the exte nally-geared wheel, B, which is also loose, and carries a stud axle, G, upon which runs the pi ion, D. The pinion, C, is fixed to the shaft and communicates mot on to the wheel A through the pinion D, so long as the wheel B is held. In Herr Coerper's arrangement the wheel B is held by a brake or allowed to slip therein. In the device shown in Fig. 4, the wheel B is held by the pinion E, fixed to the spindle, H, which carries also the wheel F. This wheel F bears upon the cone, except when the maximum speed is desired for A, when it is held fast by a brake. If any change in velocity is required, the brake is removed and the cone, K, by the same movement brought into contact with the wheel F. This wheel is thus put into motion, and the pinion E permits the wheel B to rotate at a speed which depends upon the diameter of the part of the cone brought into contact with F. By this means it will be seen that a r tative circuit is completed between the wheel B, loose upon the shaft, and the cone, K, fixed thereto, and the work done upon pinion E, which replaces Herr Coerper's friction brake, is put back into the shaft, S, by means of the cone. The teeth, J on A, are chain gear teeth. Fig. 5 shows the direction of rotation of the shaft and wheels, A, B, C, and D. Fig. 6 only shows an epicycle train instead of the cyclical train shown in Fig. 4. We may say the whole apparatus is fully described in Patent Specification, No. 5,736, of 1886.

WOODHOUSE AND RAWSON'S DISTANT ELECTRIC GAS LIGHTER.

We illustrate herewith the distant electric gas-lighter of Messrs. Woodhouse and Rawson, recently used on Nairn Pier and other places. The method of use is ingenious, and

Electric Gas-lighter.

very simple. Three or four Leclanché cells are connected to the distant point, at which is fixed the apparatus shown in Fig. 1, which contains a small electro-magnet and ratchet wheel, fixed to an ordinary burner. The action of the magnet temporarily breaks the circuit, and in so doing touches a short spring wire to the gas burner. A coil of ordinary No. 16 insulated wire, 8in. long, is interposed in the circuit near the battery. This is a simple primary coil, but the act of suddenly breaking circuit induces a secondary spark, and so lights the gas. The push, Fig. 2, is arranged

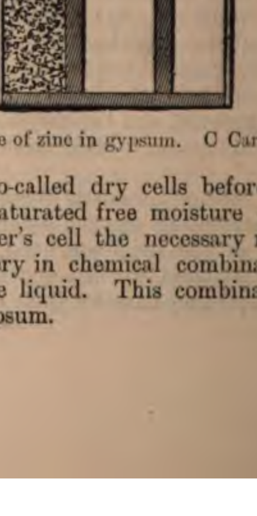
Black and White Push for Electric Gas-lighter.

with two buttons, white and black. The white push turns the gas on and lights it, the black push turns it out. The apparatus acts practically automatically at any distance.

GASSNER'S DRY BATTERY.

The ideal seems the not impossible in electricity. We have looked for the ideal dynamo, and, apparently, not altogether in vain. If what we learn about Dr. Gassner's dry battery is true, we, perhaps, have here the ideal battery. The principal of Staaten Island Academy—wherever that is—says so, and, indeed, we are inclined to agree if the results bear out the statements. But one modification is needed at the outset. Let us whisper to the primary battery syndicates this battery is *not* for lighting incandescent lamps; it is not an electric lighting battery at all, it is for ringing bells. We are told it has rung a bell wound to a resistance of 20 ohms for sixty days continuously, and was not exhausted. It has also driven a primary clock for thirteen months, and still gives forth its current. It is intended to replace the Leclanché cell, which is fragile, and liable to spill if broken, and does not last so long without attention.

Dr. Gassner's Dry Cell.



Z Zinc. O Oxide of zinc in gypsum. C Carbon Cylinder.

We have had so-called dry cells before, whose action depends upon the saturated free moisture of a mixture in the cell. In Gassner's cell the necessary moisture is contained in the battery in chemical combination, and not in the form of a free liquid. This combination consists of oxide of zinc in gypsum.

The glass containing cell is done away, and the outer cell consists of the zinc element itself in the form of a solid zinc cylinder. This has insulating material inside, covering the bottom, and the carbon block rests upon this, the space being filled with the special preparation, and the top being securely cemented up. Such a cell can be used in any position, and is not affected by alteration of temperatures. When at rest, no chemical action appears to occur at all, and the porous mass does not form any deposit on the zinc—a common fault with dry batteries, and one which tends to rapidly increase the resistance and decrease the current.

When exhausted, the battery will act as a secondary cell or accumulator, and may be renovated by passing a current from Bunsen's cells, tests taken by Prof. Gerard, of Liège University, showing that 92 per cent. of this energy can be recovered.

The following tests have been made by Prof. Gerard :—

E.M.F. at starting	1·508 volts.
Internal resistance	0·21 ohms.

The element was put on short circuit.

Time.	E.M.F. (Daniell's.)
0	1·508
5 seconds	1·36
1 minute	0·935
2 minutes	0·800
3 "	0·682
4½ "	0·680
5 "	0·632
10 "	0·525
15 "	0·433

On open circuit it recovered itself as follows :—

Time.	E.M.F.
1 minute	0·641
3 minutes	0·791
5 "	0·850
3 hours 30 minutes	1·265

After being put again on short circuit for eighteen hours, the E.M.F. fell to 0·1015 volts, furnishing altogether 45 e.h.p. (3,376 kilogrammetres) of work. Here the regeneration by means of the charging current was resorted to, with a current of 5 amperes, and resulted in a rise in thirty minutes to 1·680 volts, and after four hours further charging with 1 ampere it showed an E.M.F. of 2 volts. It was here discharged on short circuit, falling in fifteen minutes to 0·77 volts, and after eighteen hours to 0·1 volts, returning, as before mentioned, 92 per cent. of the energy received. The regenerated element is even better than the freshly-formed element.

The length of time this battery can be run continuously, its portability and its immunity from damage, should make it an exceedingly useful addition in its special department.

THE TESLA ALTERNATE CURRENT MOTOR.

Dr. Louis Duncan gives the following further note on the Tesla motor :

"Since writing my last note on this motor Mr. Tesla has read an interesting description of his system before the Institute of Electrical Engineers, and in his answer to the note referred to he has further described his motors. The study of both of these papers has increased my admiration for the simplicity and success of his system.

"The motor discussed in my last note was of the synchronous type with two short-circuited coils at right angles to one another. Further, Mr. Tesla in his paper before the Institute of Electrical Engineers states that 'in a general distributing system of this kind the following plan should be adopted. . . . The motors operated from this generator should be of the synchronous type, but possessing sufficient rotary effort to insure starting.' So I will reconsider the statements I made in the previous note with reference to this type, and try to see if they should be modified. With respect to my views as to the theory of such a motor, they look at the phenomena from a different stantpoint from that taken in Mr. Tesla's paper, and an unfortunate misprint ('It' for 'I,' the symbol used to represent current) greatly obscures the meaning. Apart from this, my conclusions were that it was doubtful if such a motor would start under load—meaning to attain its proper number of revolutions—that if a load of great inertia be suddenly applied so that the motor is called on for more than its maximum load, it will stop or take up some slower speed; and finally, that the currents do not decrease in proportion to the load. Now, the first two questions can be settled so easily and simply by experiment, that it is hardly worth while attempting to evolve reasons for believing one way or the other. The way I would look at it is this: The motor combines a synchronous and non-synchronous part. The former does little work until the motor reaches its normal speed ; the latter does considerable work until the motor reaches a speed lower than the normal by an amount depending on the load. Now, how is the speed to jump from this lower value, at which equilibrium is reached, to the normal value? It might do so in a number of cases where the inertia is great; in others I must confess to doubts. As to the second point, my objection follows directly from what I have said above.

"With respect to the consumption of current at small loads, I think that in any synchronous motor, the effect of decreasing load is simply to decrease the difference between two quantities of work—one plus, the other minus—that the motor does. If this is the case, the currents should not vary in proportion to the load, but should be greater in proportion with smaller loads.

"With respect to the non-synchronous motors, however, I have very little but admiration to express. I cannot help thinking that they can be governed without resorting to synchronism, and in this case they will have advantages that will greatly aid in the advance of electric distribution.

"Finally, I must confess to some disappointment that no data has been given as to the performance of Mr. Tesla's motors. One cannot, of course, expect from machines that are just emerging from an experimental state the efficiency and output that they will finally attain, but a few curves of the currents in the magnets and armature coils under different conditions would tell us more of the possibilities and directions of improvement than could any amount of discussion.

"In the meantime, I would congratulate Mr. Tesla on the discovery and application of a novel means of obtaining continuous rotation from alternating currents, and I shall watch the further development of his system with interest."

INDICATOR MAGNET.

We illustrate below an indicator magnet devised by Mr. J. T. Todman, of Messrs. Mayfield and Co., which presents some points of interest on account of the ease and certainty of its movement. The white card bearing the figure is shown in back position in the cut; it is mounted on a

Indicator Magnet.

revolving arm actuated by a spring, and is released from a projecting stud when the magnet acts upon the armature. The core of the magnet is hollow, and the stud is carried below into the inside of the magnet, which thus acts also as a solenoid, starting the motion of the armature at the slightest contact of the circuit. This apparatus, mounted with a small dry battery, makes a very cheap and effective indicator.

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NOTICE.

With our issue of January 6 we gave a Portrait of E. GRAVES, ESQ., *President of the Society of Telegraph Engineers, and stated our intention of giving a series of Portraits of eminent Electricians of the century. In fulfilment of our promise we have already issued a Portrait of* W. H. WOLLASTON, M.D., F.R.S., *and on April 20th we gave that of* SIR HUMPHRY DAVY, F.R.S., *whose fame as an electrician is still more prominent than that of* WOLLASTON. *Portraits of Past Presidents of the Society are in preparation, and we hope soon to have ready that of* PROF. D. E. HUGHES, F.R.S.

DETAILS.

Wellington's success is said to have been largely due to his attention to details. Nothing seemed too large or too small for him to consider. The engineer who plans an electric light installation has somewhat the character of a general in that he has to arrange satisfactorily a number of details, which, acting harmoniously together, result in a successful scheme, while, on the other hand, if the parts are not carefully considered in connection with the whole, trouble is likely to arise and failure result. There is no royal road to success, and it must not be expected that a number of pieces of apparatus brought together at haphazard when put together will give a very satisfactory performance. No rule is said to be without exceptions, and certainly there are men both amongst those who call themselves amateurs and amongst those who are strictly professional, who are adepts at making the most incongruous materials and apparatus suit their requirements and work admirably. The real engineer will no more think of makeshifts in permanent work, than the general will advise declaring war against a strong power when there are no soldiers except militia, and no guns except the antediluvian Brown Bess. There is hardly an engineer of repute but who has had to contend against "failure." The word has an ugly look, but it remains, and nothing can hide it or even put it into the background. A single failure is more damaging to a young industry than can be compensated for by a hundred successes. Look at our contemporaries devoted to the gas industry. Week in and week out they hunt out every failure they can find, and pervert the meaning of the criticism of the technical press into something never contemplated by the critic. They fasten and fatten on the failures to our detriment. Though if we are not in error, by far the larger number of failures are due to neglect of details. The dynamo, lamps, and wiring may be perfect; but, to save a few pounds, an engine is obtained from a second-class, instead of a first-class maker. Again, the engine may be of the best make, and the dynamo faulty, or the wiring carelessly carried out, the leakage too great, and the demand upon engine and dynamo greater than they can supply. Usually, however, the failure arises not from any inherent weakness in these, the principal parts of the installation, but in the matter of contacts and cut-outs.

One of the fundamental principles to be respected in an electric light installation is publicity. Nothing should be hidden or put away in such a manner that it cannot be easily examined. A part of the daily routine should be rigid inspection and careful report. We have not yet arrived at that stage of perfection that any part of the installation can be permitted to look after itself. This fact seems to us self-evident, but in several cases that have come under our notice,

both as regards house and ship lighting, the wires have been so built in, that ship or house would have to be pulled almost to pieces to get at them should anything go wrong. In overhead wires breakdowns have occurred through carelessness in not running the wires to the insulators. Cases are well known where wires not damp-proof have been run in places where dampness was the prevailing rule and not the exception. A short time since an engineer stood by watching the laying and insulating of an electric light cable in a trough under the roadway. His description of the scene was one of utter carelessness and incompetency, and that the manner in which the cable was laid must lead to many troubles. We are not sure, indeed, but that he described the cable as being so carelessly laid that in one or two cases he noticed it was not in the trough at all. We were unable to ascertain whether this particular work was by contract or otherwise, but we have no hesitation in saying, from the description of the work given to us, that the last cost of that cable will be greater than the first. There are two classes of break-downs, one of which can be minimised, if not entirely eradicated, by the constant attention to details; the other cannot be so obviated, but the former class is immeasurably more numerous than the latter, so that we may rest contented till the latter develops, if we can only get rid of the other. There are cases in which the installation is wilfully injured. Pity 'tis that such an accusation may be made in the latter end of the nineteenth century, but among such instances we may cite the severance of a wire by means of a hatchet, which caused a stoppage of half-an-hour in a town installation. No amount of care can forsee such acts as this; but we may hope that the record will not be further lengthened. Some years ago a well-known master at a public school read a paper before a society of his colleagues, and chose for his text "trifles," arriving at the conclusion that the success of a schoolmaster depended very much upon the attention he gave to "trifles." Without assenting to this conclusion unreservedly, we do really think that the success of an electrical, or in fact any other, engineer depends very largely upon his attention to "trifles," though in this case we should prefer "trifles" to be spelt "details."

CORRESPONDENCE.

DYNAMOMETERS.

To the Editor of The Electrical Engineer.

Sir,—At pp. 536 and 537 of your impression of the 8th inst. you describe and illustrate a form of dynamometer, which you mention as White's. I believe you will find that the credit of this invention is due to John Elce. Dynamometers of this form were registered in November, 1849, No. 2090, and were made by John Elce and Co., at the Phœnix Park Iron Works, Jersey-street, Manchester, and were more particularly used for ascertaining in mills and factories the power required to drive spinning and other machinery in their places.—Yours, &c.,

229, Norwood-road, S.E. W. Worby Beaumont.

DEVICE FOR THE DETECTION OF HOT BEARINGS.

To the Editor of The Electrical Engineer.

Sir,—In your last issue there appears a note descriptive of a "Device for the Detection of Hot Bearings." Why do not inventors better employ their time than in inventing ingenious devices for which there is no demand? I do not speak alone from my own experience in suggesting that a device to indicate a hot bearing is uncalled for, but also from the long experiences of men whose business it has been to look after engines and machinery. What an engine driver or a machine man wants to know is when any bearing *begins* to run hot, and by hot I mean hotter than usual for that particular bearing. No two bearings run exactly alike. What might be considered cool for one would probably be dangerously warm for another. What, then, is the good of an indicator which gives a signal at a certain standard temperature? Take the case of a main bearing or a crank-pin, we should have no indication that it was becoming hot, but when the mischief was done the bell would ring. The engine itself would tell us this by dragging. Besides the inutility of such devices, we introduce with them a new evil—that is, they would tend to make engine drivers careless and neglect to pay that attention to the machinery which they otherwise would. The most efficient and reliable detector for hot bearings is the hand, and any man who is fit to be left in charge of an engine will go round as regularly as clockwork and feel the bearings; he thus knows the condition of each one and the probabilities of any of them running hot. I know of an installation which runs twenty hours a day and seven days a week in which hot bearings never occur, but if these automatic detectors were introduced I doubt if it would continue to enjoy this reputation.—Yours, &c.,

London, W. F. Broadbent.

INCANDESCENT LAMPS v. FIRE RISKS.

To the Editor of The Electrical Engineer.

Sir,—Having been away from England for some time past the report upon M. Mascart's experiment relative to the above subject, which appeared in your journal of May 18th last (page 459), only came under my notice this morning, hence delay in writing; but as the subject is an important one, permit me to point out that danger from fire is entirely obviated if a double glass lamp globe is used. This is easily accomplished at about a penny extra cost, by the lampmakers blowing one tube within another of slightly smaller diameter, so as to cover, as it were, an outer shell over the lamp bulb.

I may mention that this class of lamp was patented by me in 1883. The following is the description set forth in the specification—viz.:

"The globe, or bulb, of this lamp is made either of clear or of coloured glass, and is surrounded by a glass globe or covering same in such a manner as to leave a space between the two globes for the passage of air. By these means, the outer globe, or covering, is kept cool, and is, therefore, not liable to be cracked or broken by water dropping upon it. Moreover, the risk of explosion will be diminished, because, should the lamp receive a blow sufficient to break the outer globe, the inner globe will still serve as a protection against the ignition of gas by the incandescent filament."

This special class of lamp has a treble advantage:

1st. It prevents the breakage of lamp bulbs holding the filament by any sudden splashing of water thereon.

2nd. The hollow space between the two holes keeps the outer jacket cool, and thus prevents any injurious effect by undue heat.

3rd. When used as a safety lamp in mines, it tends to pre: vent explosions by the heated filament not coming in direct communication with fire-damp in case of fracture of bulb.

For high candle-power lamps of 100 c.p. and upwards, the Westinghouse and Seel types, in which double filaments are used, have considerable advantage, as less heat is generated in lamps of this class; but in the new class of lamps now made of the non-vacuum type, the bulbs of which are filled with attenuated gases or expansive ethereal vapour, the large bulb, as suggested by M. Mascart, is an advantage, as it holds a larger quantity of carbon-feeding vapour

therein enclosed, and therefore prolongs the life of the filament, and not only tends to prevent air wasting, but also prevents disintegration of the conductors used to produce the light.

M. Mascart has evidently overlooked the value of keeping the lamp bulbs as small as possible if high vacuo is sought to be attained; but as the modern methods of lamp manufacture, according to the present state of the art, have considerable advantages over the old sys'ems, the question of high vacuo is not of such importance, as is generally supposed, now that other discoveries have been brought into practice, as now known and adopted in incandescent lamp manufacture. If you can find space in your next issue, please insert this, and oblige—Yours, &c.,

June 28. ARTHUR SHIPPEY.

EFFECTS OF DIFFERENT POSITIVE METALS, ETC., UPON THE CHANGES OF POTENTIAL OF VOLTAIC COUPLES.*

BY DR. G. GORE, F.R.S.

In this research numerous measurements were made, and are given in a series of tables, of the effects upon the minimum point of change of potential of a voltaic couple in distilled water (Royal Soc. *Proc.*, June 14, 1888), and upon the change of electromotive force attending variation of strength of its exciting liquid (*ibid*), obtained by varying the kind of positive and of negative metal of the couple, and by employing different galvanometers. The measurements were made by the method of balance through a galvanometer, with the aid of a suitable thermo-electric pile (Birmingham Philos. Soc. *Proc.*, vol. iv., p. 130, *The Electrician*, 1884, vol. xi., p. 414). The kinds of galvanometer employed were an ordinary astatic one of 100 ohms resistance, and a Thomson's reflecting one of 3,040 ohms resistance.

The following were the proportions of hydrochloric acid (HCl.) required to change the potential of different voltaic couples in water :—

Table I.—Hydrochloric Acid.

	Astatic galvanometer.	Reflecting galvanometer.
	Between	Between
Zn + Pt	1 in 9,300,000 and 9,388,185	1 in 15,500,000 and 23,250,000
Cd + Pt	1 ,, 574,000 ,, 637,000	1 ,, 1,662,500 ,, 1,550,000
Mg + Pt	1 ,, 516,666 ,, 574,000	1 ,, 775,000 ,, 930,000
Al + Pt	1 ,, 12,109 ,, 15,000	1 ,, 42,568 ,, 46 500

With iodine and the astatic galvanometer the following proportions were required :—

Table II.—Iodine.

Zn + Pt	between	1 in	2,100,000	and	3,521,970
Mg + Pt	,,	1 ,,	577,711	,,	643,153
Cd + Pt	,,	1 ,,	200,431	,,	224,637

With bromine and the astatic galvanometer :—

Table III.—Bromine.

Mg + Pt	between	1 in	310,000,000	and	344,444.444
Zn + Pt	,,	1 ,,	77,500,000	,,	84,545,000
Cd + Pt	,,	1 ,,	3,470,112	,,	3,875,000

The magnitudes of the minimum proportions of bromine required to change the potentials of the three couples in water, varied directly as the atomic weights of the three positive metals.

With chlorine, the following were the minimum proportions required :—

Table IV.—Chlorine.

With the reflecting galvanometer.					
Mg + Pt	between	1 in	27,062,000,000	and	32,291,000,000
With the astatic galvanometer.					
Mg + Pt	between	1 in	17,000,000,000	,,	17,612,000,000
Zn + Pt	,,	1 ,,	1,264,000,(00	,,	1,300,000 000
Zn + Au	,,	1 ,,	518,587,360	,,	550.513,022
Cd + Pt	,,	1 ,,	8,733,585	,,	9,270,833
Zn + Cd	,,	1 ,,	55,436	,,	76,467

In the case of chlorine, as well as that of bromine, the magnitudes of the minimum proportions of substance required to change the potential of magnesium-platinum, zinc-platinum, and cadmium-platinum varied directly as the atomic weights of the positive metals.

The examples contained in the paper show that the proportion of the same exciting liquid necessary to disturb the potential of a voltaic couple in water, varied with each different positive or negative metal; and that the more positive or more easily corroded the positive metal, or the more negative and less easily corroded the negative one, the smaller usually was the minimum proportion of dissolved substance necessary to change the potential.

By plotting the results in all cases, it was found that the order of change of potential, caused by uniform change of strength of liquid, varied with each positive metal.

The results also show that the degree of sensitiveness of the arrangement for detecting the minimum point of change of potential, depends largely upon the kind of galvanometer employed.

As a more sensitive galvanometer enables us to detect a change of potential caused by a much smaller proportion of material, and as the proportion of substance capable of detection is smaller the greater the free chemical energy of each of the uniting bodies (Roy. Soc. *Proc.*, June 14, 1888), it is probable that the electromotive force really begins to change with the very smallest addition of the substance, and might be detected if our means of detection were sufficiently sensitive, or the free chemical energy of the uniting bodies was sufficiently strong.

* Abstract of Paper read before the Royal Society, June 21, 1888.

THE "VOLTAIC BALANCE."

BY DR. G. GORE, F.R.S.

A new and simple lecture experiment is to take two small clean glass cups containing distilled water; simultaneously immerse in each a small voltaic couple composed of either unamalgamated magnesium or zinc with platinum, taking care that the two pieces of each metal are cut from the same piece and are perfectly clean and alike. Oppose the currents of the two couples to each other through a sufficiently sensitive galvanometer, so that they balance each other and the needle does not move. Now dip the end of a slender glass rod into a very weak aqueous solution of chlorine, bromine, iodine, or hydrochloric acid, and then into the water of one of the cups. The voltaic balance is at once upset, as indicated by the movement of the needle, and may be shown to a large audience by means of the usual contrivances.

The chief circumstance to be noticed is the extremely great degree of sensitiveness of the arrangement in certain cases; this is shown by the following instances of the minimum proportions of substance required to upset the balance, with an ordinary astatic galvanometer of 100 ohms resistance, and with a Thomson's reflecting one of 3,040 ohms resistance.

1. *Zinc and Platinum with Iodine.* — With the astatic galvanometer, between one part of iodine in 3,100,000 and 3,521,970 parts of water.

2. *Zinc and Platinum with Hydrochloric Acid.*—With the astatic galvanometer, between one in 9,300,000 and 9,388,185 parts ; and with the reflecting one, between one in 15,500,000 and 23,250,000 parts.

3. *Magnesium and Platinum with Bromine.*— With the astatic galvanometer, between one in 310,000,000 and 344,444,444 parts.

4. *Zinc and Platinum with Chlorine.*—With the astatic galvanometer, between one in 1,264,000,000 and 1,300,000,000 parts.

5. *Magnesium and Platinum with Chlorine.*—With the astatic galvanometer, between one in 17,000,000,000 and 17,612,000,000 parts. And with the reflecting one, between one in 27,062,000,000 and 32,291,000,000 parts of water.

Every different soluble substance requires a different proportion, and with unlike substances the difference of proportion is extremely great. With solutions of neutral salts, the proportion of substance required to upset the balance is large; for instance, with chlorate of potash, a zinc-platinum couple, and the astatic galvanometer, it lay between one part in 221 and 258 parts of water.

The degree of sensitiveness of the balance is usually greater, the greater the degree of chemical affinity the dissolved substance has for the positive metal, and the less it has for the negative one.

By first bringing the balance with a magnesium-platinum couple and the astatic galvanometer nearly to the upsetting point, by adding one part of chlorine to 17,612 million parts of water, and then increasing the proportion to one in 17,000 millions, the influence of the difference, or of one part in 500,000 millions, was distinctly detected.

PROTECTION OF BUILDINGS FROM LIGHTNING.*

BY PROF. OLIVER J. LODGE, D.SC., F.R.S.

Lecture II.

I made several assertions last week which it is my business now to justify by actual experiment.

The word "inertia" one uses as conveying a correct general notion of the behaviour of an electric circuit to sudden electromotive forces, a behaviour which is caused by the influence or induction which every portion of a circuit exerts on every other portion. Consider a conducting rod as analysed into a bundle of parallel wires or filaments, and let a current be suddenly started in all. The rising current in any one filament exerts an opposing force on all the others; and this self-generated opposition E.M.F., due to induction between the different filaments of the conductor, exactly imitates the effects of ordinary inertia as observed in massive bodies submitted to sudden mechanical forces. (For some illustrations of these well-known effects see a letter by Mr. Maclean in *Nature*, vol. 37, p. 612).

The term commonly employed to denote the electrical inertia-like effect is "self-induction," which is becoming gradually shortened to "inductance"; its original form when first dealt with by Sir William Thomson was the "electro-magnetic capacity" of the circuit.

Now, since electric inertia is due to a mutual action between the filaments into which a conductor may be supposed divided, it is manifest that the closer packed they are the greater their inertia will be; and that to diminish inertia it is only necessary to separate the filaments and spread them out.

The main count of the indictment against ordinary procedure is, that too much attention has been hitherto paid to conducting power, and too little to inertia. In fact, it is not too much to say that practically nothing but conductivity has been attended to, or thought of, in the erection of lightning conductors.

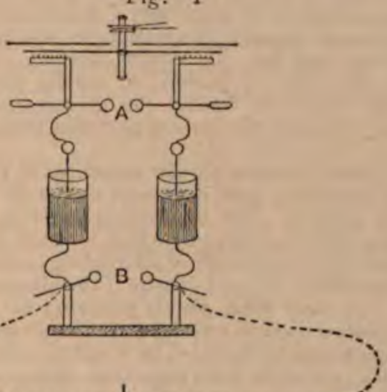
I want to show that conductivity is from many points of view of hardly any moment, and that the circumstances of a discharge are regulated far more by inertia than by conductivity. I can even show that under certain circumstances high conductivity appears to be an actual objection, and that a stout rod of good conducting copper carries off a flash less well and quietly than a thin wire of badly-conducting iron.

Let us proceed to verify this paradoxical statement at once.

Experiment of the Alternative Path.

The first form of experiment I have to describe is a very simple one. I call it the experiment of the alternative path. It consists in giving a Leyden-jar discharge the choice between a certain conductor and a certain length of air, and in adjusting the length of air until it had as lief take one path as the other.

Fig. I



I am not aware that the particular mode of carrying out this simple experiment has any special significance, but, to be definite, I depict, in Fig. 1, the symmetrical arrangement I have most frequently, though not exclusively, adopted.

The knobs marked A are the ordinary terminals of a Voss machine. The jars stand on ordinary wood table, and their outer coats are led to the discharger, B, the distance of whose air-space can be varied. The alternative path, L, is shown by a dotted line. The discharge has to choose between B and L. Sometimes L is absent, and in that case the charging of the jars is quite well effected through the wood of the table; this is the advantage of having the jars imperfectly insulated. At the same time the conducting power of the wood is too low to enable the jars to discharge themselves at all satisfactorily, unless the knobs, B, are within striking distance, or unless some path, L, is provided. The only discharge obtained at A when both paths B and L are absent, is a feeble spitting or intermittent and frequent sparking, very different from the loud report heard as soon as the knobs B are brought within striking distance. But it is not to be supposed that the B knobs must be as close together as the A knobs in order to permit complete discharge; on the contrary, the B knobs may be almost twice as far apart as the A knobs, and yet the discharge shall be complete and noisy.

It will be understood that the two sparks occur together: a spark at A precipitates, and is the cause of, the spark at B—not *vice versâ*, for until the A spark occurs there is not the slightest tendency for a spark at B. The two B knobs are at the same zero potential, and may be touched with impunity except at the instant when the flash occurs at A. Remember that the jars are standing on a common table all the time.

Lest it be thought that there is anything occult in this mode of obtaining the spark at B, let us subjoin, as Fig. 2, another arrangement of connection, which does just as well, and, in fact, represents the first experiment I tried. The condenser is a very large one of tinfoil and glass plates, with carefully insulated terminals. My object in making it was to obtain a sudden rush of a considerable quantity of electricity (like lightning), and then study its behaviour under various circumstances. I found afterwards that for most experiments an ordinary gallon or even pint Leyden jar served just as well, was much quicker in use, and less dangerous. Moreover, the use of insulated terminals necessitates the continued presence of some alternate path, L, or other, else, of course, the condenser declines to charge.

It may be noted at once that with either arrangement the spark, A, was very loud whenever the spark was allowed to occur at B as well; but so soon as the discharge was compelled to traverse the alternative conductor, L, by putting the B knobs too far apart, then the noise of the discharge was much diminished, not merely because there is now only one spark instead of two, but plainly because, for some reason or other, the discharge meets with considerable obstruction in the wire, whereby its duration is lengthened, and its noise therefore very greatly lessened.

The numbers given below are extracted from a page of the laboratory note-book, and refer to an experiment with two Leyden jars, of a size which I sufficiently specify by calling them "gallon" jars, arranged as in Fig. 1. The length of the A spark was maintained at one inch throughout the experiment; or as it happened to be accidentally convenient to measure lengths in tenths of an inch, I will call the A length 10. The B length is variable, being altered until a B spark sometimes passes and sometimes misses.

The first alternative path I show is a length of about 40ft. of stout No. 1 (B.W.G.) copper wire or rod, suspended round the room by silk ribbon. Its resistance to ordinary currents is very small, between ·025 ohms. Nevertheless, we shall find that the discharge refuses to take this apparently easy path, and persists in jumping the air gap, B, instead, until the B knobs are separated 14·3 tenths of an inch. This is the critical distance. If they are further apart than this, the discharge chooses the thick copper wire by preference, and its noise or suddenness is then much less.

As a contrast with this, I next try a similar length of fine iron wire (No. 27, B.W.G.), whose resistance to ordinary currents is 33·3 ohms, or 1,300 times as great as the other. We find that the discharge very distinctly prefers this wire to the other. For if the B knobs remain at the distance 14·3 we never now get a B spark, nor do we get one until they have been brought distinctly nearer. The critical spark length is now 10·3. I confess I was surprised at this result.

Let us next try an enormous resistance—a capillary tube of liquid (very dilute acid), giving to ordinary measurements some 300,000 ohms. The critical spark length at B is indeed a little increased by this great resistance, but not much above that found for the stout copper wire. I have not an exact measure of it, but sixteen or seventeen will not be far out. The spark at A now becomes very quiet indeed, pointing to the fact that what we were observing all along was in some sense or other the effect of true resistance, for the undeniable resistance in the capillary tube gives just the same kind of effects as does the copper or iron wire, only a little more pronounced.

I have suspended three other conductors of about the same length, which it is easy to try in the same way, keeping the A spark-length 10 all the time. The results are here summarised:—

Alternative Path.		Critical B spark-length.
Stout copper wire	No. 1 R = ·025 ohm ...	14·3
Ordinary copper wire,	No. 19 R = 2·72 ,, ...	13·4
Stout iron wire	No. 1 R = ·086 ,, ...	10·8
Ordinary iron wire	No. 18 R = 3·55 ,, ...	10·8
Thinnest iron wire	No. 27 R = 33·3 ,, ...	10·3

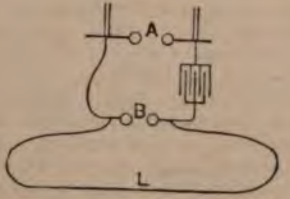
The copper wires seem to obstruct almost equally, and the iron wires also obstruct equally among themselves, notwithstanding their very different diameters; but the coppers obstruct more than the irons.

There is nothing absolute about these numbers; they are the record of a definite experiment, but their precise value depends on the circumstances of the experiment. It is easy to arrange it so that the iron is less effective than the copper—so that, in

* Dr. Mann Lectures, delivered March 19, before the Society of Arts.

fact, ordinary resistance seems to become of consequence again. This is done by putting a long lead into the A circuit of the jars. But whenever the flash is made as sudden as possible—and there seems little doubt but that a lightning flash is very

FIG. 2.



sudden—then the order of the numbers is something like the figures quoted.

REASON OF THE ENORMOUS OBSTRUCTION OFFERED BY A GOOD CONDUCTOR.

Now, what is the cause of all this astonishing obstruction offered by good conductors to the sudden rush of electricity? One may express it in a popular way, thus: It is due to electrical inertia, or what is also called "self-induction." A current cannot start in a conductor instantaneously, any more than water in a pipe can start moving at full speed in an instant. Give the water a violent blow to make it move, and its resists like a solid. The blow, if very quick and violent, may burst the pipe, but it will not appreciably propel the water. So, in a manner, is it with electricity. The flash occurs, and the conductor must either carry it off at once or not at all. There is no time to think about it, and the E.M.F. needed to overcome this inertia-like obstruction is so great, that a considerable thickness of air may be burst by it, and the discharge may flash off sideways to anything handy.

Another way of putting the matter is this: A lightning discharge is essentially a varying current. It manifestly rises from zero to a maximum, and then dies away again, all in some extremely small fraction of a second, say 100,000th, or thereabouts. But that is not all; there is a certain amount of energy to be got rid of, to be dissipated, and it may easily be that a single rush of electricity in one direction does not suffice to dissipate all the stored-up energy of the charged cloud. If the conductor is highly resisting, a single rush is sufficient, but if it be well-conducting it is quite insufficient. What happens then? The same as would happen with compressed air or other fluid rushing out of an orifice. If it is a narrow jet, there is a one-directioned blast; but if a wide, free mouth be suddenly opened, the escaping air overshoots itself by reason of inertia, and springs back again, oscillating to and fro till the stored-up energy is dissipated. Just so is it with an electric discharge through good conductors. It is not a mere one-directioned rush, it is an oscillation, a surging of electricity to and fro, until all the energy is turned into heat.

This fact is often forgotten by lightning-rod men. They speak as if there were a certain quantity of electricity to be conveyed to earth, and there was an end of it; but they forget the energy of the electric charge, which must be got rid of somehow. If a great weight, or a large reservoir of water, were propped up above one's house, one would not say that, the safe thing being to get it down as quickly as possible, it was advisable to knock the props away, or to blow the bottom out of the reservoir; no, one would prefer to let it slide slowly and gradually down a well-resisting channel, so as to disperse the energy gradually.

We will remember, then, that a Leyden-jar discharge through good conductors is oscillatory, and that the oscillation continues until all the stored energy is rubbed away. The oscillations have an enormous frequency; they may be millions a second, for the whole lot of them have to cease during the excessively minute duration of the visible flash. It is well known that a flash is of far less real duration than the persistence of optical impression on the retina would lead one to believe; as is easily illustrated by illuminating a spinning wheel by an electric spark. However fast (ordinarily speaking) the wheel is spinning it appears to be stationary, and the spokes are seen singly and clearly by the light of each spark.

It is for this reason that, although the illuminating power of a powerful flash need not be greater than weak moonlight, its actual intensity while it lasts may exceed strong sunlight, and hence may exert a damaging effect on the retina, and cause blindness.

There is another fact which it behoves us to be aware of. It is one to the importance of which the attention of scientific men has but recently been called. Experimentally it has been discovered by Prof. Hughes; theoretically by Mr. Oliver Heaviside, Lord Rayleigh, and Prof. Poynting; for, though the necessary theory is really contained in Clerk Maxwell, it required digging out and displaying. This has now been abundantly done, but the knowledge has scarcely yet penetrated to practical men—indeed, it has not yet been thoroughly assimilated by most physicists. The fact is this. When a current starts in a conductor, it does not start equally all through its section; it begins on the outside, and then gradually, though rapidly, penetrates to the interior. A steady current flows uniformly through the whole section of a conductor; a variable current does not. It is started first at the surface, and it is stopped first at the surface.

Remembering the rapidly oscillating character of an electric discharge, remembering also the fact that a rising current begins on the outside surface of a conductor, we perceive that, with a certain rate of alternation, no current will be able to penetrate below the most superficial layer or outer skin of the conductor at all. In the outer skin, of microscopic thickness, electricity will be oscillating to and fro, but the interior of the conductor will remain stolidly inert and take no part in the action.

Thus we arrive at a curious kind of resistance, caused by inertia in a roundabout fashion, and yet a real resistance, a reduction in the conducting substance of a rod, so that no portion, except that close to the surface, can take any part in the conduction of these rapidly alternating currents or discharges. It must naturally be better, therefore, not to make a lightning conductor of solid rod, but to flatten it out into a thin sheet, or cut it into detached wires; any plan for increasing surface and spreading it out laterally will be an improvement.

Perhaps it may be as well to guard against one favourite misconception. It has long been known that static charges exist only on the surface of conductors; it has also long been known that ordinary currents flow through the whole section and substance of their conductors. It is now beginning to be known that alternating currents may be sufficiently rapid to traverse only the outer layers of conductors, and this last piece of knowledge is felt to be rather disturbing by those who have been accustomed to dwell upon the behaviour of steady currents, and seems like a return to electrostatic notions, and an attempt to lord it over currents by their help. But the first and third facts mentioned above—the behaviour of static charges, and the behaviour of alternating currents—are two distinct facts, independent of each other; not rigorously independent perhaps, but best considered so for ordinary purposes of explanation.

We have thus mentioned two causes of obstruction met with by rapidly oscillating currents trying to traverse a metal rod. First, there is the direct inertia-like effect of self-induction to be added to the resistance proper; the resulting quantity being called by Mr. Heaviside "impedance," to distinguish it from resistance proper. For there is a very clear distinction between them; resistance proper dissipates the energy of a current into heat, according to Joule's law, impedance obstructs the current, but does not dissipate energy. Impedance causes tendency to side flash, resistance causes a conductor to heat and perhaps to melt. The greater the resistance of a conductor, the more quickly will the energy of a discharge be dissipated, its oscillations being rapidly damped; the greater the impedance of a conductor, the less able is it to carry off a flash, and neighbouring semi-conductors are accordingly exposed to the more danger. Resistance is analogous to friction in machinery; impedance is analogous to freely suspended massive obstruction, in addition to whatever friction there may be. To slowly changing forces friction is practically the sole obstruction; to rapidly alternating forces inertia may constitute by far the greater part of the total obstruction; so much the greater part that friction need hardly matter.

This is a fairly accurate popular statement of the direct way in which self-induction aids resistance proper in obstructing an alternating current. But in addition to these considerations there is that other indirect way which we have also mentioned, viz., the fact that conduction of alternating current may be confined to the surface of a rod or wire if the alternations are rapid enough. This cause must plainly increase total impedance, for the total channel open to such a current is virtually throttled, as a water-pipe would be throttled by a central solid core.

But which part of the total impedance does it affect? Does it increase the resistance part or the inertia part? In other words, does this throttling of a conductor act by dissipation of energy or by mere massive sluggishness? Plainly, it must act like any other reduction of section, it must increase the resistance, the dissipating power of a conductor, the heating power of a current. Hence the resistance of which we have spoken as entering into the total impedance has by no means the same value as it has for steady currents, and as measured by a Wheatstone bridge. It is a quantity greater—possibly much greater—than this; and in order to calculate its value, we must know not only the sectional area and specific conductivity of the conductor but also the shape of its section and the rate of alternation of the current to be conveyed.

TAPE v. ROD.

We may here note a vigorous controversy, or difference of opinion, between Faraday on the one hand, and Sir W. Snow Harris on the other. Faraday was often consulted about lightning conductors for lighthouses, and consistently maintained that sectional area was the one thing necessary, weight per linear foot, and that shape was wholly indifferent. Harris, on the contrary, maintained that tube conductors were just as good as solid rods, and that flattened ribbon was better still. Each

is reported to have said that the other knew nothing at all about the matter. Of course we know that Faraday was thinking of nothing but conduction, and conduction for steady currents. Harris had probably no theoretical reason to give, but was guided either by instinct or by the result of experience. I think we shall have to admit that, in this particular, Faraday was wrong and Harris was right. The following experiment may serve to illustrate the point further :—

I take two copper conductors of the same length and approximately of the same weight, but one of them in the form of wire, the other in the form of ribbon, and I use them successfully as an alternative path. The knobs at A being fixed at two centimetres apart, the B knobs were adjusted until the spark sometimes chose the air gap, and sometimes the alternative conductor. (See Fig. 1 or 2.) The critical B spark-length was then :—

	Millimetres.
With the wire as alternative path	8·36
With the ribbon ,, ,, ...	6·26
,, wire ,, ,, ...	8·45
,, ribbon ,, ,, ...	6·05
,, wire ,, ,, ...	8·21
,, ribbon ,, ,, ...	6·06

Very distinctly showing the advantage of a flattened form of conductor over a mere round section.

The dimensions of the two conductors here compared are as follows :—Wire : No. 12 B.W.G., 218 centimetres long, weight 91·6 grammes. Ribbon : 218 centimetres long and 6·4 centimetres broad, weight 88·7 grammes.

But, it may be said, have not experiments often been made as to the advantage of tape over rod forms of lightning conductor, with negative results? Yes ; but the point usually attended to is the deflagration of the conductor. Mr. Preece, for instance, with Dr. De la Rue's battery, found ribbon and wire equally easy to deflagrate by the discharge. But we are not examining which form of conductor is least liable to be destroyed by a flash—probably there is not much to choose between one form of section and another, for there is no time for surface cooling—we are examining which form will carry off a charge most easily, and with least liability to side-flash ; and here thin ribbon shows distinct advantage over round rod.

Iron *v.* Copper.

You remember we have found that a rod of iron carries off a discharge more satisfactorily than a rod of copper. It would seem as if the poorer conducting qualities of iron enabled the discharge to penetrate deeper, and so to make use of a greater thickness of skin.

But everyone will say—and I should have said before trying—Surely iron has far more self-induction than copper. A current going through iron has to magnetise it in concentric cylinders, and this takes time. But experiment declares against this view for the case of Leyden jar discharges. Iron is experimentally better than copper. It would seem, then, that the flash is too quick to magnetise the iron ; or else the current confines itself so entirely to the outer skin that there is nothing to magnetise. A tubular current would magnetise nothing inside it. Somehow or other the peculiar properties of iron, due to its great magnetic permeability, disappear.

I do not believe anyone could have expected this result. Possibly Lord Rayleigh might have predicted it, and perhaps Mr. Oliver Heaviside. It would scarcely become me to express admiration for the work of so great a master of science as Lord Rayleigh (though, parenthetically, I may mention that I feel such admiration in the highest degree), but I must take the opportunity to remark what a singular insight into the intricacies of the subject, and what a masterly grasp of a most difficult theory, are to be found among the eccentric, and in some respects repellent, writings of Mr. Oliver Heaviside. I cannot pretend to have done more than skim these writings, however, for I find Lord Rayleigh's papers, in so far as they cover the same ground, so much pleasanter and easier to read ; though, indeed, they are none of the easiest.

Can this suggestion with regard to iron be examined and verified or disproved in some other more direct way?

It is easy to try another experiment. I have here two conductors made of tinfoil ; each is made of a long slip of tinfoil, about 3in. broad, and 21ft. long. One is zigzagged backwards and forwards, with the interposition of three thicknesses of paraffin paper between each zigzag to insure insulation, so as to abolish self-induction as far as possible. This I call the tinfoil zigzag. The other is coiled spirally on a glass tube—again with the interposition of paraffin paper—so as to give as much self-induction as possible. This I call the tinfoil spiral. A bundle of fine iron wires—the core of an induction coil, in fact—can be introduced into this glass tube, or withdrawn at pleasure. The resistances of these conductors, measured in the ordinary way, are :—·614 ohms for the spiral, and ·708 ohms for the zigzag. They were intended to be alike.

The connections being made as in Fig. 1, one or other of these tinfoil conductors is used as the alternative path, L, with this result :—

The length of the A spark being 7·3, the critical spark-length at B, when sparks sometimes passed and sometimes failed, was 11·1 when no alternative path was provided. When the tinfoil zigzag connected the outsides of the jars instead of the wire, L, it was not possible to get a B spark till the distance was shortened to 0·6 ; when this was replaced by the tinfoil spiral, the critical B spark-length rose to 6·4. The iron bundle was now inserted in the spiral, and the experiment tried again. The B spark-length remained 6·4. The iron made no perceptible difference whatever.

Here is a magnetic time-lag raised to an extreme. Prof. Ayrton tells me they have noticed the permeability of iron begin to diminish with very quick alternations. Here it is becoming virtually no bigger than that of air. It may be said that the iron fails to get magnetised because of the opposing action of the inverse "Foucault" currents induced in it, just half a period behind the inducing currents. I thought this would be so, of course, with thick rods of iron, but with a bundle of thin wires I felt doubtful. Lord Rayleigh, however, thinks these induced peripheral currents competent to explain magnetic time-lag in every case ; and I can have no doubt that he is right. Whatever the explanation, the fact of time-lag in iron is patent. Yet there is something strange about it, for that a steel knitting-needle can be magnetised by discharging a Leyden jar round it is mentioned in every text-book, and (what does not necessarily follow) it is certainly true. There are points here requiring further examination.

However, if it turns out to be true that an iron rod does not get magnetised by the passage of a rapidly alternating current, it may be held a natural consequence of the fact that such currents flow mainly in its outer surface, and that such tubular currents have no magnetising power on anything inside them.

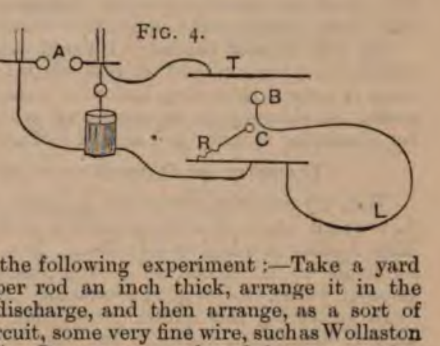
The magnetisability of iron is no objection to its employment in lightning conductors. Its inferior conductivity is an advantage in rendering the flash slower, and therefore less explosive. Its high melting point and cheapness are obvious advantages. It is almost as permanent as copper, at least, when galvanised ; and it is not likely to be stolen. I regard the use of copper for lightning conductors as doomed.

Experiment of the Bye-Path.

We have seen that a conductor is more efficient in carrying off a discharge and preventing side-flash, in proportion as its self-induction is lessened—say, by spreading it out into a thin sheet, or cutting it up into a number of wires, or otherwise. But no conductor is able to prevent side-flash altogether, unless it is zigzagged to and fro so as to have practically no self-induction ; in that case the side spark is nearly stopped. But so long as a conductor is straight (and a lightning conductor must, of course, be straight), so long will there be some tendency to side-flash, however thick it be made. It may be a foot or a yard thick, and yet not stop it.

Fig. 3.

Fig. 4.



One may easily try the following experiment :—Take a yard of stout brass or copper rod an inch thick, arrange it in the path of a Leyden jar discharge, and then arrange, as a sort of bye-path or tapping circuit, some very fine wire, such as Wollaston platinum wire (Fig. 3). It may seem absurd for any portion of the discharge to leave the massive rod and take the hair-like wire by preference, especially if an air-gap exists at A or at B, or at both. Nevertheless, a portion *does* choose the fine wire path, and you get a little spark at A or at B about a sixteenth of an inch long. One may vary the experiment by trying to get a shock by holding two different parts of a thick copper rod through which a discharge is passing. The mere difference of potential between conductor and earth must, of course, be avoided. It is not easy to get an appreciable shock from a few yards of very stout conductor ; still, it can be done. Holding two points of a stout open spiral, consisting of about five yards of No. 1 copper wire, connected to earth, a faint shock can be felt with wetted hands whenever a Leyden jar is discharged through the copper. No doubt with a very large condenser the shock would be quite noticeable ; and a man touching a lightning conductor, however well earthed, might perhaps receive a shock sufficient to kill him. At all events, I should not care to try the experiment with a real lightning flash.

Experiment of the Side-Flash.

Let me illustrate the tendency to side-flash by a more directly applicable looking experiment. Fig. 4 shows a couple of tin-plates or tea-trays fixed a foot or so apart, one earthed, the

other insulated. They obviously represent one a charged cloud, the other a layer of thoroughly good conducting earth. A lightning conductor, B L, is provided; L consisting of a considerable length of stout copper wire or rod. At C a possible side path is provided, so that, if the flash chooses, some of it can spit off through an inch or so of air, and through an interposed resistance, R, to earth. A side flash, C, is found to occur unless the sparking distance is made too great; and the effect of increasing R is not to stop the side flash, but to weaken it. Thus, even with the liquid resistance of nearly a megohm at R, an inch spark still passes at C for every flash at B, though the C spark is now very weak.

How can this tendency to side-flash be further diminished? At the end of the last lecture I hinted at a partial remedy—elasticity. To stop a pipe full of water from being burst by a blow given to the water, you will make the pipe elastic. An elastic cushion will ease off the violence of the shock of a water-ram.

Electric inertia was known by the other name of self-induction; electric "elasticity" is known by the other name of capacity. Increase the capacity—not the thickness or conducting power, but the electrostatic capacity of your conductor—and it will be able to carry off more.

This phrase, "the capacity of a conductor," when used by the old electricians, commonly signified merely its conducting power, this being the sole thing most of them thought of; but using it in its modern signification let us see what advantage is to be gained by increasing the capacity of a conductor—say, by connecting to its two ends the coatings of a Leyden jar.

Take the No. 18 wire round the room and use it as an alternative path, as in Fig. 1, first without a jar connected to its ends, then with a jar. Length of spark at A, 5·35 tenths of an inch; corresponding critical B spark length :—

Iron wire without jar, 6·5;
Iron wire with jar, 5·0.

Not a very great difference. Not so great a difference as would be gained by diminishing the self-induction by flattening the wire out in foil. Still, it is in the right direction, and we see what we have to do: diminish self-induction as far as possible, and increase capacity whenever convenient. One may also try the experiment by attaching a jar to the conductor B, in Fig. 4: the side flash, C, is somewhat shortened.

But of an actual lightning conductor, how is it possible to increase the capacity? There is no sense in surrounding it with an earth tube, because that, after all, would only act as an additional conductor, and might as well be so considered from the first. Neither does a great series of polarisable voltameter plates seem a feasible suggestion. No; the only practicable plan is to expand it over as much surface as possible. A lead roof, for instance, affords an expansion of fair capacity which may be easily utilised; and there should be as little mere rod projection as possible before some extent of surface begins. Flat sheet for chimneys is better than round rod—it has at least *some* more capacity and much less self-induction.

For tall isolated chimneys I would suggest a collar of sheet metal round the top, and at intervals all the way down; or a warp of several thin wires instead of a single rod, joined together round the chimney by an occasional woof; or any other plan for increasing capacity and area of surface as much as possible.

Liability of Objects to be Struck.

Now, try experiments on the liability of things to be struck. Is a small knob at a low elevation as liable to be struck as a large surface at a higher elevation? Is a badly-conducting body as liable to be struck as a well-conducting one? In other popular words, does a good conductor "attract lightning"?

In answering this question experimentally, we must draw a careful distinction between the case of a flash occurring from an already charged surface, which has strained the air close to bursting point before any flash occurs, and the case of a flash produced by a rush of electricity into a previously uncharged conductor too hastily for it to prepare any carefully-chosen path by induction. The two cases are: 1st, steady strain; 2nd, impulsive rush. Take them separately.

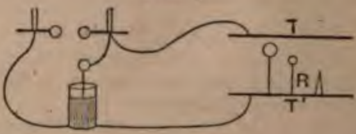
First with Steady Strain.

First, an experiment on the liability of things to be struck when the air above them is in a state of steady strain gradually increased. I take the two tin plates, arranged one over the other, and stand between them three conductors, one ending in a large knob, a second ending in a small knob, and the third ending in a point (Fig. 5).

The experiment consists in working up the charge of a jar attached to the top plate until discharge occurs, and in adjusting the three conductors so that they may be indiscriminately struck. One finds that the point, even when very low, prevents discharge altogether. It may indeed be too low to be effective; or, again, it may be insufficient to cope with the supply of electricity; but we see here the well-known function of a point—prevention of discharge. Remove or cover up the point now, and attend only to the large and small knobs. If the knobs are negative and the plate above them positive, brush discharge goes on from the knobs, and it is not easy to get a long flash; but by reversing the connections the tendency to brush is greatly lessened, and we now get flashes some three or four inches long. But always to the small knob. The small knob has to be pulled down about three times as far from the charged surface as the big knob is before it ceases to protect the big knob, and the latter is then for the first time struck. This occurred, for instance, when the distance of the big knob from the top plate was 9, and the distance of the small one 29½ (tenths of an inch). They were then either of them struck indiscriminately. If the little knob was any taller than 29½, it alone was struck.

Now, what is the effect of resistance upon the protecting power of the point or small knob? Scarcely any. Instead of connecting the small knob direct to the bottom tray, connect it through the liquid megohm, R, and it gets struck just as easily as before.

Fig. 5



Here are distance readings when they get struck with equal ease:—Large knob distance, 7·5; small knob distance, with high resistance, 22·0. The point protects both up to distance 60·0, until covered up by a thimble.

Thus, the flash actually prefers to jump three times as much air, and encounter a megohm resistance, rather than take the short direct path offered by the bigger knob. The sizes of the knobs in this experiment are:—1·27in. diameter for big knob, and ·56in. for small knob.

Of course, the cause of this is well known. It is merely that the air breaks down at the weakest point—viz., on the surface of one of the knobs, and the tension on the small knob is much greater than that on the big one for a given difference of potential. The fact that the discharge begins in the air above the conductor explains why it is that adding resistance—even enormous resistance—to a conductor makes no difference to the length of the spark which strikes it. The path is prepared inductively in the air, and the resistance of the path which the discharge must ultimately take makes no difference, provided it is not so nearly infinite as to prevent the free adjustment of the static charges and inductions set up as the machine is worked. But though high resistance makes no difference to the length of the spark, it does affect its noise and violence. The discharge striking the small knob has now only a soft velvety noise. Its energy, or heating effect, is much the same, but its suddenness, and, therefore, its noise and violence, are enormously lessened.

This water resistance is equivalent to a shocking bad earth; and its effect is, we see, to make the spark gentle. But it is an evident advantage to have a discharge take this quiet and manageable form. The worse a conductor is, the quieter will be the flash; and, up to a certain limit, it will protect just as well apparently. Hence, surely, a bad earth is an advantage. But wait a bit; we have not yet considered the other case—the impulsive rush.

Second, with Impulsive Rush.

Let us now modify the experiment to try the second form of the experiment—the impulsive rush.

Fig. 6.

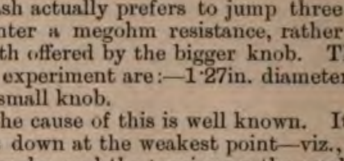


Fig. 6 shows the connections. There is no difference of potential between the trays up to the very instant of discharge. The jars gradually charge up (they stand on the same wooden table), and ultimately discharge at A. A violent rush then takes place into the two plates, and the conductors between are struck. Adjust them till they are all struck with equal ease, as before; we find the conditions utterly different. No longer does the small knob protect the taller big knob; no longer does the point exert any special protective influence. All three bodies—large knob, small knob, point—are equally liable to be struck if at the same height, and no one is more liable than another; simply the highest is struck if they are at all equally conducting. It is easy to get all three struck at once. Now make one bad conducting, and its protective virtue is gone. Putting the liquid megohm into any one of the three conductors, and that one is no longer struck. It ceases to protect the other two, even if taller than they; nay, even if it be raised so as to *touch* the top tray, thus establishing direct conducting communication of a poor kind between cloud and earth, still

next to none of the flash chooses that path, and the other two conductors get struck with apparently just the same ease as before. This is the real objection to a bad earth; it cannot protect well against these sudden rushes.

Sudden rushes are liable to occur; the clouds spark first into one another, and then, as a sort of secondary effort or back kick, into the earth. For instance, two clouds, one above the other; the top cloud sparks into the lower, and this at once overflows to the earth. In these cases the best conducting and highest objects are struck, quite irrespective of any question of points and knobs. Points are no safeguard against these flashes, as you see. The point gets struck by a vivid flash, exactly of the same character as that which strikes one of the knobs; it has no time to give brushes or glows; its special efficacy in preventing discharge exists only in the case of steady action, where the path is pre-arranged by induction. In the case of these sudden rushes, the conditions determining the path of discharge are entirely different. No doubt they have to do with what is called the "time-constant" of the various conductors.

Experiment of the Recoil Kick.

It will have been noticed that in the experiment of Fig. 1, the spark obtained at B is longer than the spark at A. And the question arises why this should be so. Plainly, what is happening is this:—The discharge at A sets up electrical oscillations, and the charge of the jars is rapidly reversed. The difference of potentials of the inner coats changes from, say, + V to nearly − V, and back again; the difference of potential of the outer coats changes, therefore, from 0 to nearly 2 V, and hence the B spark may be expected to be nearly twice as long as the A spark; and so it is.

Fig. 7.

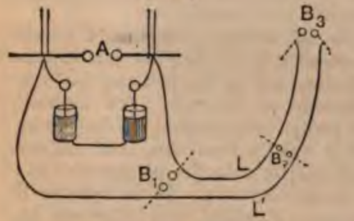
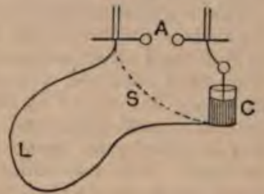


Fig. 9.



These electrical oscillations are of considerable interest, and have sundry practical bearings; let us proceed to make them more conspicuous. Fig. 7 shows a couple of long leads, L and L', reaching round the room (No. 18 wire in two 95ft. lengths was actually employed), insulated from one another and from the earth, but attached to the two poles of a machine, the machine having also a couple of Leyden jars attached to it in the customary manner when supplied by the maker. A discharger, B, can be arranged to bridge the gap between these leads, either near the machine, as B, or about the middle, as B_2, or at the far end, as B_3. Now, of course, sparks can be obtained either at A or at any of the B knobs, and all about the same length; but supposing the A knobs to be brought nearer than the B knobs, the spark would be expected to occur at A only. Nevertheless, on trying the experiment, one finds that every time a spark occurs at A, a longer spark occurs at B; it is, as it were, precipitated with a rush; and the longest spark of all is obtainable at the far end—viz., at B_3.

Here are some figures, in the obtaining of which, however, for convenience of manipulation, the B length remained constant in each position, and the least length of the determining spark, A, was the thing observed:—

Nearest position.			
Spark length A	3·20	4·15	5·12
Corresponding spark length B_1	3·22	4·80	6·18
Middle position.			
Spark length A	1·92	2·37	2·70
Corresponding spark length B_2	3·22	4·80	6·18
Furthest position.			
Spark length A	1·60	2·2	2·45
Corresponding spark length B_3	3·22	4·80	6·18

The electricity in the long wires is surging to and fro, like water in a bath when it has been tilted; and the long spark at the far end of the wires is due to the recoil impulse or kick at the reflexion of the wave. Evidently, there are some quantitative relations to be specified here, and there will be some best capacity of the jars corresponding to a given length of conductor, and to a given arrangement of main discharge circuit A. The nearer the length of the conductors corresponds to a half-wave length, or some multiple of a half-wave length of the oscillations produced by the discharging jars, the more perfect will be the synchronism between the pulses, and a longer recoil kick may be expected. The arrangement may, in fact, be compared to a resonant tube excited by a tuning fork or reed, to Melde's experiment with vibrating strings, or to any other case of forced vibration.

The following numbers will just serve to show some difference of effect caused by different sizes of jars. Using two pint jars in series, and fixing the A spark at 4·5, the B_3 spark at the far end just ceases when the knobs are pulled out to 7·8. But, replacing the pint jars by gallon jars, the B_3 spark does not cease till the knobs are separated to 10·9, the corresponding spark in the position B_1 being only a trifle longer than the A spark—viz., 4·7.

It is not to be supposed, however, that by increasing the capacity of the jars still farther, a still better effect will be obtained; for on replacing the two gallon jars by the very large condenser of alternate glass and tinfoil sheets, we find the spark at B_3 fails when the knobs are only 5·9 tenths of an inch apart; the length of the A spark remaining 4·5, as before.

There is, as I say, a quantitative relation; and it is a relation which the modern theory of electricity makes known. I cannot go into it here, but I may just say that, very approximately, the wave-length of the electrical oscillation of a discharging jar is 2π times the geometric mean of the static capacity of the jar and the electro-magnetic inertia of the discharger.

The capacity of the two gallon jars in series (this being the capacity which gave the best result with 95ft. of leads) was about ·002 microfarad, or, say, 1,800 centimetres; hence, supposing the wave length of their discharge through the A knobs to be something like 190 or 200ft. (twice the length of the leads), we should calculate the self-induction of the circuit formed by the jars, short connecting wires, and A knobs, as something like five metres, which is a reasonable enough value.*

Repeating the experiment, Fig. 7, with the two gallon jars in series, but insulated this time from the earth, a still longer spark at B_3, the far ends of the long wires, can be obtained—viz., A = 4·5, B_3 = 14; and even when the knobs of the discharger are separated beyond this distance, a brush still passes between them for every spark at A.

Removing the discharger altogether, and making the experiment in the dark, a very interesting effect is seen; the further end of each wire glows with a vivid brush light, showing the exceedingly high potential to which they are raised by the recoil. I do not see the effect with thick No. 1 wires, but with No. 18 wires it is very marked. The glow on each of the two wires is independent of the position of the other; thus, if the connections are made so that the wires run opposite ways right round the room from the machine, the distant end being insulated, it is still the end of each furthest from the machine that glows, although they are separated from one another, for most of their length, by the whole width of the room. With the two-gallon jars the wires glow over fully three-fifths of their entire length. With jars of much larger or much smaller capacity the length of glow is conspicuously less.

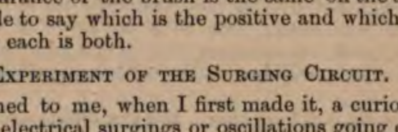
Connect a small pint jar to the ends of the wires, and all these effects cease. The increase of static capacity reduces their potential below the brushing point. Arranging the jar so as to leave an air space between it and one of the wires, a spark passes into it at each A spark; but the jar is not the least charged afterwards—proving that the spark is a double one, first in and then out of the jar, a real recoil of a reflected pulse. Hence it is also that the appearance of the brush is the same on the two wires—one is not able to say which is the positive and which the negative wire, for each is both.

Experiment of the Surging Circuit.

What seemed to me, when I first made it, a curious illustration of these electrical surgings or oscillations going on in a conductor which is being suddenly discharged at one end, is afforded by the following extremely simple experiment.

Attach one end of a long insulated wire to the machine, and connect the other pole of the machine to earth. Jars connected up also to the machine do no harm, but they are unnecessary. The wire now practically constitutes one coating of a condenser, of which the walls of the room are the outer coat. The wire is made to form a nearly closed circuit, and its further end brought within an inch or so of the near end, as at B (Fig. 8).

Fig. 8.



Under these circumstances one would at first sight say that a spark at B was absurd, for the two knobs are metallically connected through a stout conductor, which may be No. 1 wire, and not necessarily many yards long. Nevertheless, it will be found that sparks at B can be obtained quite as long, though not quite as strong as those at A. Every A spark is accompanied by a B spark, unless, of course, the knobs are too far separated.

* Since the delivery of the lecture, a great number of quantitative observations on these lines have been made. Evidence of electro-magnetic waves thirty yards long has been obtained. I expect to get them still shorter.

One may surmise that it is the static charge on the distant portion of the conductor which, having to rush toward A, prefers the short path, B, instead of the longer path *via* the wire. But this is not the whole account of the matter, as can be shown by interposing high resistance in the conductor at various points; say, at the places 1, 2, 3, or 4 (Fig. 8). Introducing a quarter of a megohm at the point 1 or at 3 weakens the B spark very much, and apparently about the same whether it be at 1 or at 3; the strength (*i.e.*, the noise and appearance) of the A spark remaining much the same. Introducing a high resistance at the point 4, weakens both the A and the B sparks. Introducing a high resistance at the point 2, leaves both sparks pretty much as strong as they were without it.

The spark at B is caused by electrical oscillation—a surging of the charge of the wire to and fro like water in a pipe. One might liken it to an elastic pipe pumped very full of water, and its end closed with spring valves. If, then, one end is suddenly opened and shut, a pulse is transmitted through the pipe, which may force open the valve at the far end and let some water escape.

It is these electrical oscillations, I doubt not, which account for the long spark obtained by the use of a "Winter's ring."

This last experiment, Fig. 8, however it may be explained, has an obvious application to the question of connecting roof gutters to lightning-conductors. It is most desirable to connect them, but both ends should be connected. If only one is connected, the far end is very likely to spit off a flash.

Again, we see how, when a flash strikes a system, the electricity goes rushing and swinging about everywhere for no apparent reason, just as water might surge about in a bath or system of canals into which a mass of rock had just dropped, splashing and overflowing its banks. Just so with electricity. Bell-wires, gas-pipes, roof-gutters, conduct side-flashes in a way most puzzling to the older electricians; and thus gas may get ignited in the most unexpected places, and passengers in a train may feel a shock because a charge has struck the rails. In powder magazines it is apparent how dangerous this lawless sparking tendency may be; for even the hinge of a door may furnish opportunity for some trivial spark sufficient to ignite powder. By no means, it seems to me, should high rods be stuck up to invite a flash to such places. Build them, or line them, with connected iron, barb them all over the roof, connect them to the deep ground in many places, and I don't see what more can be done.

Experiments on Overflow of Jar.

Another way of making these electrical surgings more conspicuous is by their effect in causing a jar to overflow—*i.e.*, to spark round its edge. The overflow of a common jar is, in fact, very like a lightning flash, for it is a discharge direct between two coatings. That is just what a lightning flash is. There is ordinarily no conductor present except the two coatings—the clouds and the earth. I found a curious remark in Franklin* about the overflow or fracture of Leyden jars. He found that when one broke from overcharging, a great number went together; *and also that the spark in the ordinary circuit did not fail.* He was led by this observation to doubt if the breakage of the jar was really due to a discharge of the electricity through it, and he surmises that it may be due to a sudden expansion of air-bubbles in the interior, suddenly relieved of the strain.

No doubt he is wrong there, but the observation of the facts is good and noteworthy. We will repeat the experiment. It is not necessary to burst the jars; overflow round the edge is just as good, and cheaper. The overflow experiment can be put into a variety of forms; perhaps it will be sufficient if I show the simplest.

Fig. 9 shows the arrangement. It consists in nothing but establishing the connection between the machine and one or both of the coatings of a jar through a long wire instead of a short one as usual. If one connects the jar, C, by the dotted line, it does not overflow until the spark-length A is very great; but with a long lead, L, to make the connection, a very short spark at A will cause the jar to overflow or discharge round its edge.

Here are a few numbers. The jar is one of the gallon jars, with the glass fully three inches above the tinfoil, so that, when it overflows, the spark has to strike along fully six inches of glass. When L is the thick No. 1 copper circuit round the room the jar overflows every time an A spark occurs, even though the length of this A spark is only ·64 of an inch. Short-circuit out the long lead, as shown by the dotted line, and the jar refuses to overflow until the A spark-length has been increased to 1·7; and when it does overflow now the violence is very considerable. Remove short-circuit again, and the jar overflows in ever so many places at once with great violence, a perfect cascade of flashes leaping round the edge. Bring the A knobs nearer together, and the overflow does not wholly cease till their distance apart is again ·62. On another occasion one got for the A spark-length sufficient to cause overflow of jar:—

56 with the long lead.
1·7 with an ordinary short wire.

* "Franklin's Works," by Sparks, 1840., vol. v., page 475.

With a small pint jar, and a less height of glass above its coatings, I took the following readings:—Length of A spark sufficient to cause overflow—

·67 with iron wire round room.
·52 with copper ,,
1·40 with short circuit.

Fig. 10 shows very well, in a diagrammatic fashion, the effect of long leads in causing a jar to overflow, or, of course, to burst if the glass edges are too tall for the thickness and homogeneity of the glass to stand.

Fig. 10

A are the machine terminals, B those of a discharger, and J_A and J_B are two jars connected up by fairly long leads. Now, of course, sparks may be obtained either at A or at B, one as easily as the other, and one of the jars is liable to overflow, but not both. It is the jar J_B which overflows when a spark occurs at A. It is the jar J_A which is made to overflow by a spark at B. It might be thought that if the B knobs were fairly near together, a spark at A might precipitate a spark at B, instead of making J_B overflow; but it is not so. The event is not, indeed, impossible by any means, if the B knobs are pretty near together; but it is easier for the jar to overflow by direct discharge between its coating over a space of some 6in., than it is for it to discharge through the wire and rods of the discharger, and an air-space of an inch, or even less. It is not easy to help a jar to overflow by discharging-tongs. Even a foot of conducting wire is a great obstruction to the passage of the flash; it greatly prefers direct discharge through air unobstructed by the self-induction confinement of a conductor.

This is also illustrated by the extraordinary length of insulating surface which is found necessary in the Leyden jars supplied to Holtz and other such machines, and by the fact that such jars often flash even over a foot instead of through a few inches of air space led up to by the proper discharging-knobs—though indeed, it must be noticed, as it was by Franklin, that the overflow of a jar by no means necessarily robs the proper circuit of its flash. The two things occur together. It is usually the spark which causes the overflow. Perhaps one may say that the case of discharge direct between coatings without any conductor, accounts in some measure for the extraordinary length and unexpected paths of some lightning flashes.

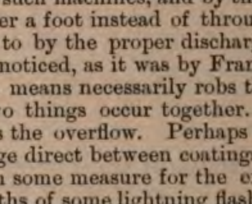
These electrical oscillations and overflows, which it is thus easy to set up in a charged conductor, manifestly explain what is known as the "return stroke." I pointed out in Lecture I. that the ordinary explanation of the return stroke, the recovery of electrical equillibrium disturbed by static induction, was by no means able to account for effects of the least violence; but this fact, that a discharge from any one point of a conductor may cause such a disturbance and surging as to precipitate a much longer flash from a distant part of it, at once accounts for any "return stroke" that has ever been observed.

It is for this reason that I think it possible a tall chimney or other protuberance in one's neighbourhood may be a source of mild danger; inasmuch as if it is struck it may be the means of splashing out some more discharges to other smaller prominences, which otherwise were beyond striking distance. It is in this way, also, that I imagine multiple flashes, such as those referred to in Lecture I., are produced. I liken them to the cascade of flashes rushing over the sides of a jar, when connected up with a long lead, and when the A spark is pretty long.

Experiment of the Gauze House.

Finally, we have to ask, Is it possible for the interior of a thoroughly enclosed metal room to be struck, or, rather, can a

Fig. 11.



small fraction of a lightning flash find its way into a perfectly enclosed metal cavity; for instance, a spark strong enough to ignite some gun-cotton in a metal-covered magazine which might happen to be struck?

It is not easy, but it can be done, at least under such conditions as are likely to obtain in practice it can be done. My friend, Mr. Chattock, to whom I am indebted for much kindly assistance and suggestion, has made the experiment in the form shown in Fig. 11.

A metal gauze cylinder, with tin plate ends, has a couple of conductors, one soldered to each end, protruding into the interior, so as to approach very near each other, and these are the conductors put into the path of the discharge. If both conductors are entirely enclosed in the metal chamber, we have not yet succeeded in getting a spark between them; but if either of them protrude any portion of their length outside the chamber, then sparks in the chamber can be obtained.

In Fig. 11 the conductor, N M B, is shown thus protruding, penetrating the chamber through a small glass tube near M, but soldered to it near N. E F is a movable arm or radius, making contact with this conductor. If contact is made near M, it takes a very strong A spark to give any spark at B inside the gauze cylinder; but as the contact from F is shifted towards N, it becomes very easy to get a small spark at B.

The application of this to powder magazines is that if any conductor (like a gas-pipe) pass out of the building before being thoroughly connected with its walls, it is possible for a spark to pass from something in the interior of the building to this conductor whenever a flash strikes the building. We thus find that the complete and certain protection of buildings from lightning is by no means so easy a matter as the older electricians thought it.

In many cases we may be content to fail of absolute security, and be satisfied with the probable safeguard of a common galvanised iron rod or rope. But for tall and important buildings, for isolated chimneys and steeples, and for powder magazines, where the very best arrangement is desirable, what is one to recommend? I prefer to call attention to principles rather than to advocate any particular nostrum; but inasmuch as my present opinion is not likely to carry any undue weight, there is no harm in my saying that I see nothing better than a number of lengths of common telegraph wire. I think a number of thin wires far preferable to a single thick one; and their capacity must be increased, when possible, by connecting up large metallic masses, such as lead roofs and the like. But the connection should be thorough, and made at many points, or sparks may result. Balconies, and other prominent and accessible places, should not be connected.

The earth should be deep enough to avoid damage to surface-soil, foundations, and gas and water mains. As to the roof, I would run barbed wire all round its eaves and ridges, so as to expose innumerable points, and the highest parts of the building must be specially protected; but I would run no rods up above the highest points of the building, so as to precipitate flashes which else might not occur, in search for a delusive area of protection which has no existence.

The conductors must not be so thin as to be melted or deflagrated by the flash; but really melting is not a very likely occurrence, and even if it does occur, the house is still protected; the discharge is over by the time the wire has deflagrated. The objection to melting is twofold. First, the red-hot globules of molten metal, which, after all, are not usually very dangerous out-of-doors; and, secondly, the trouble of replacing the wire. I should be content to put up a great number of telegraph wire conductors, and wait till one is melted, before thinking too much of the likelihood of such an occurrence. The few instances ordinarily quoted of damage to lightning conductors by a flash do not turn out very impressive or alarming when analysed.

In conclusion, I trust that the men of experience in these matters who are present will consider the facts and suggestions I have brought forward as objects worthy of attention and further inquiry, and will study them in the light of their experience.* But as to the quack receipts and dogmatic statements which I may incidentally and without authority have provisionally given, there is no need for me to ask practical men to treat these with the contempt they no doubt deserve.

* At the second lecture I learnt that some experiments on lightning protectors, something like those of mine on "the alternative path," had been made previously by Prof. Hughes and M. Guillemin (address to telegraph-engineers). Also I find that Dr. Hertz has made experiments on electric oscillations very like those of mine on "the surging circuit" (Wied. *Ann.*, 1887). In a subsequent communication I hope to notice some of the observations of Prof. Hughes.

PROVISIONAL PATENTS, 1888.

JUNE 15.

8751. **An improvement in the Wheatstone automatic system of telegraphic transmission by which it is adapted for use on submarine cables in connection with the "siphon recorder" and "mirror" systems.** Thomas James Wilmot, Waterville, Kerry.

8765. **Improvements in holders for incandescent electric lamps.** Walter Rowbotham and William Fox, 39, Lever-street, Manchester.

8772. **Improvements in electrical switches.** Walter Rowbotham and William Fox, 39, Lever-street, Manchester.

8784. **Improvements in systems of electrical supply.** Frederick Vilhelm Andersen and John Forwood Tafe, 47, Lincoln's-inn-fields, London.

8809. **Improvements in electric switches.** Henry Harris Lake, 45, Southampton-buildings, Middlesex. (Sigmund Bergmann, United States.)

8814. **A new or improved magazine small-arm discharged by electricity, and cartridges for the same.** Alfred Treeby, 7, Staple Inn, Middlesex.

JUNE 16.

8836. **Improved safety electrical switch and fuse box combined.** George Joseph Philpott and George Herbert Alderton, 40, Gloster-road, Brighton, Sussex.

8864. **An electric tell-tale or counter mechanism.** David Alfred Aird, 166, Fleet-street, London.

JUNE 18.

8871. **Improvements in electrical switches, commonly called electric bell pushes or presses.** James Insole Ryder, 2, North Parade, Matlock Bath, Derbyshire.

8905. **Improvements in electric batteries.** Hector Lahousse and Co. and Charles Collé, of the said firm, 47, Lincoln's-inn-fields, London.

8912. **An electric meter for registering or recording electricity.** Henry Raison, 47, Castle street, High-street, Battersea, S.W.

8919. **A new or improved type of electric cable, specially applicable for high tension alternating currents, and methods of, and apparatus for, manufacturing the same.** James Grieve Lorrain, Norfolk House, Norfolk-street, London, W.C. (La Société d'Exploitation des Câbles Electriques, Système Berthoud-Borel et Compagnie, Switzerland.)

8920. **A new or improved type of electric cable, specially applicable to long distance underground and submarine telephony.** James Grieve Lorrain, Norfolk House, Norfolk-street, London, W.C.

JUNE 19.

8950. **Improvements in applying electrical traction to pleasure, sporting, and business purposes.** Charles Barnard Burdon, 32, Holborn-hill, Higher Tranmere, Birkenhead.

JUNE 20.

9032. **Improvements in electric arc lamps.** Walter Russell Mortimer and James Holloway, 28, Southampton-buildings, Chancery-lane, London, W.C.

COMPLETE SPECIFICATIONS ACCEPTED.

MAY 17, 1887.

7185. **Improvements in electro-propulsive motors and in the application thereof to wheeled vehicles or rolling stock.** William Hopkin Akester, 57, Chancery-lane, London.

JULY 20, 1887.

10,177. **Improvements in the manufacture or treatment of porous pots, plates, or partitions for electric batteries.** Erhard Ludwig Mayer and Henry Liepmann, Norfolk House, Norfolk-street, London, W.C.

AUGUST 20, 1887.

11,390. **Improvements in the manufacture of elements or plates for secondary batteries or electrical accumulators.** James Shannan Stevenson, 47, Lincoln's-inn-fields, London.

AUGUST 22, 1887.

11,417. **Improvements in and connected with electrical connections with moving bodies.** Thomas Alexander Garrett, 80, Abingdon-road, Kensington, London, W.

AUGUST 23, 1887.

11,502. **Improvements in dynamo-electric and electro-dynamic machines.** Edward Frederick Hermann Heinrick Lauckert, 28, Southampton-buildings, Chancery-lane, London, W.C.

OCTOBER 11, 1887.

13,758. **Improvements in electrical apparatus especially applicable for use in dental operations.** Alfred Julius Boult, 323, High Holborn, Middlesex. (Elias Smith and Frederick Kimble, United States.)

SPECIFICATIONS PUBLISHED.

1882.

4362. **Distributing electricity.** L. Gaulard and J. D. Gibbs. 8d Amended specification.

1887.

4219. **Accumulators of electricity.** C. Desmazures 8d. Amended specification.

1887.

5648. **Making and breaking electric circuits.** J. H. Holmes. 8d.

10,454. **Electrical signalling apparatus.** J. T. Gent and H. G. Ellery. 8d.

1888.

5713. **Electric elevators.** J. K. Hallock and G. C. Blickensderfer. 8d.

5913. **Electric insulators.** A W. Heaviside. 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday-
3 Jan.	4%	African Direct 4%	100	102
12 Feb.	1/2	Anglo-American Brush E.L.	4	3
12 Feb.	2/0	— fully paid	5	3¾
26 April	1%	Anglo-American	100	36½
26 April	2%	— Pref.	100	60½
12 Feb., 85...	5/0	— Def.	100	11¾
28 Mar.	3/0	Brazilian Submarine.........	10	12⅝
14 June	1/0	Con Telephone & Main ...	1	¾x
15 Feb.	8/0	Cuba	10	13
28 July	10/0	— 10% Pref.	10	19½
28 Mar.	2/2½	Direct Spanish	9	3¾
28 Mar.	5/0	— 10% Pref.	10	9½
28 Mar.	2/0	Direct United States	20	8⅝
12 April	2/6	Eastern	10	11⅝
12 April	3/0	— 6% Pref.	10	15
1 Feb.	5%	— 5%, 1899	100	111
26 April	4%	— 4% Deb. Stock	100	108
26 April	5/6	Eastern Extension, Australasia & China............	10	12¾
1 Feb.	6%	— 6% Deb., 1891	100	106
3 Jan.	5%	— 5% Deb., 1900	100	103½
2 Nov.	5%	— — 1890	100	103
3 Jan.	5%	Eastern & S. African, 1900	100	106
28 Mar.	8/3	German Union	10	6⅛x
12 April	2/0	Globe Telegraph Trust......	10	5¾
12 April	3/0	— 6% Pref.	10	13⅞
30 April	5/0	Great Northern	10	14¼

Dividend.		Name.	Paid.	Price. Wednesday
1 Mar.	5%	Gt. Northern 5% Deb., '83.	100	108
29 Feb.	10/0	India Rubber, G. P. & Tel.	10	17¼
11 May	37/6	Indo-European	25	38
30 May	3/0	London Platino-Brazilian...	10	6¼
16 Mar.	5%	Maxim Weston	1	[illegible]
30 May	2½%	Oriental Telephone	11	[illegible]
26 April	4/0	Reuter's	8	8
......	...	Swan United	3½	2¾
15 Feb.	15½%	Submarine	100	145
15 Oct.	6%	Submarine Cable Trust ...	100	97
29 Feb.	36/0	Telegraph Construction ...	12	40
3 Jan.	6/0	— 6%, 1889	100	105
30 Nov.	5/0	United Telephone	5	14
......	...	West African	10	5¼
1 Mar.	5%	— 5% Debs.	100	95
29 Dec.........	6/0	West Coast of America ...	10	6¼
31 Dec.	8%	— 8% Debs.	100	117
11 May	9/	Western and Brazilian......	15	10
11 May	6/10½	— Preferred	7½	6¼
11 May	2/1½	— Deferred..................	7½	4
1 Feb.	6%	— 6% A	100	112
1 Feb.	6%	— 6% B	100	107½
......	...	West India and Panama ...	10	1
30 May	10/0	— 6% 1st Pref.	10	10⅝
13 May, '80...	...	— 6% 2nd Pref.	10	7½
2 May	7%	West Union of U.S..........	$1,000	123
1 Mar.	6%	— 6% Sterling	100	103

COMPANIES' TRAFFIC RECEIPTS.

Name.	Ending.	Amount.	Inc. or Dec.
Anglo-American	None	Published.	...
Brazilian Submarine	W. June 22 ...	£4,072	...
Cuba Submarine	M. of May ...	3,300	+ £239
Direct Spanish.....................	M. of May ...	1,800	+ 232
— United States	None	Published.	...
Eastern..............................	M. of May ...	49,003	+ 946
Eastern Extension	M. of May ...	£40,586	+ £4,091
Great Northern	M. of May ...	23,200	...
Submarine	None	Published.	
West Coast of America	M. of May ...	4,700	...
Western and Brazilian	W. June 22 ...	3,385	...
West India and Panama	F. June 15 ...	2,931	+ 139

Abbreviations: W., week; F., fortnight; M., month.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts of the Brazilian Submarine Telegraph Company for the past week amounted to £4,072.

Telephone Company of Austria.—The Telephone Company of Austria, Limited, notify that coupon No. 7 of their 5 per cent. debentures, due July 1 next, will be paid, less income-tax, on and after July 2, by Messrs. Martin and Co., 68, Lombard-street.

Western and Brazilian Telegraph Company.—The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the week ending June 22, after deducting the fifth of the gross receipts payable to the London-Platino Telegraph Company, Limited, were £3,385.

Eastern and South African Telegraph Company.—The Eastern and South African Telegraph Company notify that the coupons due July 2, on their 5 per cent. mortgage debentures, will be paid on and after that date at the banking-house of Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C.

South of England Telephone Company.—The Directors of the South of England Telephone Company, at their meeting on June 21, decided to recommend a dividend of ½ per cent. on the ordinary share capital for the year ending April 30 last, placing £500 to a reserve fund, and carrying forward £1,115. 0s. 8d., the dividend on the preference shares having already been paid.

United Telephone Co.—The report of this Company for the year ending April 30 states that capital account will show that up to April 30, 1888, the sum of £263,876 has been expended upon the works in connection with the metropolitan district and instruments on royalty in the metropolitan district and subsidiary companies, being £35,695 more than the outlay shown in the last balance-sheet. The revenue accounts, exclusive of metropolitan district royalties, show that the receipts of the Company from all sources properly attributable to the year have been £143,134, as against £130,704 in the preceding year, or an increase of £12,430, and the expenditure (including snowstorm, losses and allowances, £15,653) has been £73,519, as against £66,954, or an increase of £6,564. The working expenses for the year have been £35,725. 12s., as against £30,483. 14s. 2d. for the preceding year, or an increase of £5 240. 17s. 10d. The balance of net revenue account is £68,697, of which amount the sum of £22,377 has been absorbed by the payment of an interim dividend at the rate of 10 per cent. per annum for the first half-year ended October 31, 1887, and the Directors recommend a further dividend of 10s. per fully-paid £5 share and 5s. per part-paid share for the second half-year ended April 30, 1888, amounting to £44,755, making a total dividend of 15 per cent. for the year, leaving a balance of £1,563 to be carried forward. A sum of £14,375, being the amount received during the year as premium on new shares, has been carried direct to the reserve fund.

Telephone Company.—For a body of men so well paid as the Directors of the United Telephone Company are, they seem to know singularly little about the business of the Company. In December of 1886 there was a snowstorm. In July of 1887 the Company's annual meeting was held. The chairman, Mr. James Brand, then said: "In addition to our expenditure for working expenses we have spent £11,000 in repairs and replacements caused by the damage done to us by the snowstorms, and we have put about £5,000 to a suspense account for liabilities in connection with the snowstorms which are possible to turn up." No doubt here, evidently, that the whole loss had been provided for. But the deputy-chairman, Mr. J. Staats Forbes, was quite as emphatic. Speaking of the snowstorm—"an unparalleled calamity," he called it—he said: "I will advert only to the fact that so large a sum as £15,777, which seems to have been the cost of it, has been charged at once boldly to the revenue account." Surely, if ever a ghost was laid, this snowstorm bogey might be considered under hatches. But, no; not a bit of it! The balance-sheet of the Company is just out, *and our old friend, the snowstorm, figures for £15,653 more.* Good old snowstorm!—*Financial News.*

The International Engineering Company, Limited.—Registered by Nores and Pattison, 52, Lincoln's-inn-fields, W.C. Capital £5,000, divided into 5,000 shares of £1 each. Object: to purchase or acquire certain inventions relating to electric motors, and to means for carrying electrical batteries for driving tramway vehicles and for other purposes, invented by William Denton Sandwell; to construct, equip, and work light railways, tramways, ships, lines of telegraph, telephone, &c., and to carry on as manufacturers and suppliers of electrical, steam, or other mechanical or animal or other motive power or electricity or light. The first subscribers are:—

	Shares.
J. Drage, clerk, 26, Osborne-terrace, Clapham-road, S.W.	1
E. A. Rider, clerk, 8, Lugard-road, Queen's-road, Peckham, S.E ...	1
W. B. Pattison, solicitor, 52, Lincoln's-inn-fields, W.C.	1
J. H. Yates, teacher of music, 63, Frith-street, W...............	1
C. Wickison, housekeeper, 52, Lincoln's-inn-fields, W.C.	1
J. L. Hofman, clerk, Warwick-road, New Barnet	1
W. Davis, shorthand writer, 420, Edgware-road, N.W.	1

There shall not be less than three nor more than seven Directors, and the first shall be elected by the subscribers to the memorandum of association. The qualification shall be the holding of not less than £100 in the capital of the Company. Remuneration of Directors is not stated.